The Feed Protein Market

A Background Study

by
S. C. Hudson

Report Commissioned by
The Hon. Otto E. Lang
Minister Responsible for the Canadian Wheat Board

THE FEED PROTEIN MARKET

A BACKGROUND STUDY

REPORT COMMISSIONED BY THE HON.
OTTO E. LANG, MINISTER RESPONSIBLE
FOR THE CANADIAN WHEAT BOARD

AUTHOR

S.C. HUDSON,
CONSULTING ECONOMIST, OTTAWA

PUBLISHED BY THE OFFICE OF THE MINISTER
RESPONSIBLE FOR THE CANADIAN WHEAT BOARD
HOUSE OF COMMONS, OTTAWA

SEPTEMBER, 1972

August 18, 1972

The Honourable Otto E. Lang
Minister Responsible for the
Canadian Wheat Board
House of Commons
Ottawa, Ontario

Dear Mr. Lang:

It is my pleasure to submit the report of Dr. S.C. Hudson entitled "The Feed Protein Market".

The terms of reference were to prepare a background paper for the Food Proteins from Grains and Oilseeds Study which reviewed the significant aspects of the major feed protein markets in the world. The main objective was to assess Canada's position in feed protein production, utilization and marketing, and to identify specific areas in which Canada might enlarge its involvement.

Dr. Hudson has prepared an informative report, and it will serve as a valuable reference on this topic.

Yours truly,

W. E. Jarvis
Co-ordinator
Grains Group

TABLE OF CONTENTS

THE FEED PROTEIN MARKET

Introduction

The objective of this paper is to review significant aspects of the major feed protein markets in the world; assess Canada's position in feed protein production, utilization and marketing; and identify specific areas in which Canada might enlarge its involvement.

A greater knowledge of the digestion, absorption and use of feed by domestic animals and of the various nutrients in the feedstuffs available has resulted in considerable improvement in recent years in the efficiency in the production of animal products for human consumption. This knowledge has made possible the development of good performing rations for the different classes of farm animals at different stages of development.

The classes of nutrients recognized in making up feeding rations are proteins, carbohydrates, fats, minerals and vitamins. Of these, the carbohydrates are considered to be the key ingredient in livestock feeds, since they make up about three-quarters of the dry matter in plants and are the chief source of energy in the feed of animals. The principal sources of carbohydrates in rations are grains - barley, corn, wheat and oats - which are considered to be "high-energy" feeds, and in addition for cattle and sheep, roughages such as grass, hay or silage which are generally "low-energy" feeds requiring some additional grain to balance the energy requirement with the limited energy intake from the roughage supplied.

The proteins, which are essential for life, are of outstanding importance in livestock feeding. In addition to nitrogen, most proteins also contain sulphur and a few contain phosphorus or iron. In plants and animals, there are a great many kinds of proteins which differ from each other in composition. The complex nature of the proteins is evident from the fact that at least 23 amino acids may enter into their composition. The protein in certain feeds has insufficient amounts of some of the amino acids which animals must have. While as a result of microbial action in the rumen, ruminants are able to make all of the amino acids from other nitrogenous compounds during the digestive process, for animals with simple stomachs, like pigs and poultry, such feeds must be combined with other feeds that supply plenty of these amino acids.

Another important aspect of quality in proteins is their degree of solubility. While ruminants can digest low-soluble proteins, it is essential that pigs and poultry be provided with feeds containing proteins of high quality which are highly soluble.

Grains are the principal source of protein in feeding rations but these are normally supplemented in varying degrees by a high-protein source such as oilseed and other high protein meals. For example, barley, wheat and oats provide enough protein for an 11 per cent beef finishing ration, but for a 16 per cent pig or dairy ration, grains must be supplemented with protein from a high-protein source.

It is often necessary also to add certain minerals and vitamins to rations where the main ingredients may be deficient in this respect. Such minerals and vitamins are currently available on the market in the form of micro-premixes.

The World Supply of Food Protein

World protein requirements have been estimated roughly at over 400 million tons by the Protein Task Force.[1/] This requirement includes some 100 million tons for direct human consumption, of which 35 million tons are considered to be of animal origin. The feed and forage protein required to produce this animal protein is estimated at about 350 million tons. The actual availability of animal protein is estimated at 25 million tons and the availability of plant protein in crops commonly accepted as food is about 100 million tons.

According to available statistics, the annual world production of proteins from grains, pulses and oilseeds for the period 1961-1965 averaged 135 million tons (Table 1). Of this production, it is estimated that 74 million tons (55 per cent) is used directly for food and 62 million tons (45 per cent) as feed for livestock.

Accepting the Protein Task Force's estimate of 25 million tons of animal protein entering human consumption, this would confirm their aggregate estimate of about 100 million tons of protein for direct human consumption.

If the 62 million tons of protein from cereals, pulses and oilseeds used in the feeding of livestock is deducted from the 350 million tons of plant protein estimated by the Protein Task Force as

---

1/ N. E. Gibbons, C. P. Lentz, S. M. Martin and D. Rose, Report of Protein Task Force, Division of Biology, National Research Council of Canada, Ottawa, pp. 2-4.

Table 1: World Production of Plant Protein from Grain, Pulses and Oilseed Crops, Averages 1961-65 and 1966-70

Crop	Percent Protein	Averages 1961-65 Production Grain	Averages 1961-65 Production Protein Equiv.	Averages 1961-65 Protein Utiliz'n Food	Averages 1961-65 Protein Utiliz'n Feed	Averages 1966-70 Production Grain
	%	--	million metric tons			--
Wheat	12.7	254.3	32.3	25.8	6.5	313.6
Rye	11.9	33.8	4.0	3.2	0.8	31.2
Barley	12.0	99.5	11.9	1.2	10.7	126.2
Oats	11.0	47.8	5.2	0.5	4.7	52.3
Corn	9.0	216.4	19.5	7.8	11.7	257.8
Mixed grains	11.5	6.3	0.7	-	0.7	6.1
Millet & sorghums	11.5	75.4	8.7	6.0	2.7	88.6
Rice	7.3	253.0	18.5	16.6	1.9	283.9
Grains - Sub-total		986.5	100.8	61.1	39.7	1159.7
Pulses	23.0	41.7	9.6	9.6	-	42.2
Soybeans	36.3	32.5	11.8	2.8	9.0	43.0
Groundnuts (in shell)	29.1	15.4	4.5	3.0	1.5	16.8
Cottonseed	28.3	20.0	5.6	-	5.6	20.8
Linseed	23.0	3.4	0.8	-	0.8	3.2
Rapeseed	19.4	4.3	0.8	-	0.8	5.5
Sunflowerseed	15.9	7.4	1.1	0.6	0.5	9.7
Sesameseed	20.8	1.6	0.3	0.3	-	1.7
Palm	9.4	1.0	0.1	-	0.1	1.0
Copra	7.7	3.3	0.2	-	0.2	3.3
Oilseed crops - Sub-total		88.9	25.2	6.7	18.5	105.0
Total Crops		1117.1	135.6	77.4	58.2	1306.9
Grasses, legumes, & other wild vegetation (est.)		-	290.0	-	290.0	-
Grand Totals			425.6	77.4	348.2	

Source: Production Yearbook 1970, FAO Rome.
United States-Canadian Tables of Feed Composition, National Academy of Sciences, Washington, 1969.

the aggregate requirement for the production of world animal protein supplies, it may be reasonable to conclude that about 290 million tons of plant protein are consumed by domesticated animals ultimately used for food, in the form of grass, forage and other vegetation, most of which would be in wild form and of low nutritional value.

This rough survey of the utilization of the world supply of proteins in providing human food brings into perspective the various approaches which may be taken in ensuring that there is adequate protein in the diets of the peoples of the world. It shows the relative importance of cereals, pulses and oilseeds as sources of proteins both for direct consumption and for the production of animal proteins through livestock feeding. It also demonstrates the great potential that exists for the plant breeder to increase protein consumption through a relatively small increase in the protein content of cereals and pulses. It also indicates considerable scope for increasing the food use of high protein crops.

The provision of increased quantities of animal protein in the developed countries, most of which are located in the temperate climatic zones where grain feeding of livestock is practiced, has resulted in large part from the feeding of cereals, which have been the source of some two-thirds of the protein as well as the energy feeds required in feeding operations. The protein content for cereals varies from about 12 per cent for wheat, rye and barley to 9 per cent for corn and 7.3 per cent for rice. Pulses have about 23 per cent protein. Oilseeds, which produce

both oil and meal, vary from 36 per cent protein for soybeans to 16 per cent for sunflowerseed. Palm kernel and copra, which are tropical crops, yield 9.4 and 7.7 per cent protein respectively. With expanded acreages and improvements in protein content, both feed grains and oilseed meals will continue to serve as important complementary sources of future feed protein requirements.

It would seem also that one area of work that offers great scope for improving the efficiency of the world production of animal protein may be in improving the nutritional value of natural "range land" and in providing high-protein feeds to make up for the lack of protein in the available natural vegetation.

An indication of increasing world trends in the production of plant proteins is shown in Table 1. The world production of cereals in terms of protein equivalent increased by about 18 per cent between the period 1961-65 and 1966-70 but production of pulses varied within relatively narrow limits. Among the cereals, wheat, barley and corn all registered substantial increases in production. Production of oilseed meal increased by 20 per cent in terms of protein equivalent as a result primarily of an expansion in production of soybeans.

Changes in the regional distribution of world oilseed production in terms of oilcake equivalent are shown in Table 2. Between the period 1955-57 and 1965-67, the share of world production provided by the United States increased from 40 to 48 per cent. The annual increase in the world production of oilcake averaged 4 per cent between 1955-57 and 1965-67 but was at a considerably higher rate in most developed countries.

Table 2 - **Production of Oilseeds in Terms of Oilcake Equivalent by Region.**
Averages for 1955-57, 1960-62, and 1965-67, and annual rates of change.

Region	1955-57 Average	1960-62 Average	1965-67 Average	Share of Total 1955-57	Share of Total 1965-67	Annual rates of change 1955-57 to 1965-67	Annual rates of change 1960-62 to 1965-67
	-- 1,000 metric tons --			-- Per cent --		-- Per cent --	
United States	11,186	15,479	20,024	39.7	48.2	6.0	5.2
Canada	433	487	745	1.5	1.9	5.6	8.9
EEC	147	162	325	0.5	0.8	8.3	15.0
United Kingdom	0	0	0	0.0	0.0	--	--
Other Western Europe	162	225	265	0.6	0.6	5.1	3.2
Japan	165	147	57	0.7	0.1	-10.0	17.2
Australia, New Zealand, and South Africa	103	131	155	0.3	0.3	4.1	3.4
Total	12,196	16,631	21,571	43.3	51.9	5.9	5.4
Eastern Europe	768	886	1,297	2.7	3.1	5.4	7.9
USSR	3,001	3,297	4,395	10.7	10.6	3.9	5.9
Communist Asia	4,350	3,505	3,505	15.4	8.4	-2.1	0.0
Total	8,119	7,688	9,197	28.8	22.1	1.2	3.7
Latin America	1,783	2,386	2,850	6.3	6.9	4.8	3.6
Africa and West Asia	2,120	2,474	3,062	7.5	7.3	3.7	4.4
Other Asia	3,956	4,471	4,885	14.1	11.8	2.1	1.7
Total	7,859	9,331	10,797	27.9	26.0	3.2	3.0
World Total	28,174	33,650	41,565	100.0	100.0	4.0	4.4

Source: World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980 Foreign Agricultural Economic Report No. 71, Economic Research Service, U.S.D.A., Washington, 1971.

World Imports of Plant Proteins

The distribution of the average annual imports of plant proteins in the form of wheat, coarse grains and oilseed meals during the period 1964 to 1968 is presented in Table 3. Imports of wheat and flour, which were mostly for direct human consumption, averaged 52 million tons, containing some 6.6 million tons protein equivalent. About 30 per cent of the wheat entering into international trade was imported by the developed countries, including particularly Europe and Japan. Developing countries in Asia, Africa and South America account for 44 per cent of wheat imports and the centrally planned group of countries made up 26 per cent of wheat imported.

Total imports of coarse grains averaged 35.7 million tons while oilseed meals together with imports of oilseeds in terms of meal equivalent amounted to 18 million tons. Both of these products are used primarily for livestock feeding. Coarse grains, which are normally the principal source of both energy and protein in the feeding ration, provided an equivalent of 3.6 million tons protein. Some 8 million tons of protein were provided by the 18 million tons of oilseed meals which were imported to supplement domestically grown grains in the feeding ration.

The establishment and development of commercial livestock feeding enterprises is highly correlated with the level of overall economic development in a region as well as with its climate. In those developed regions where livestock feeding has developed into a highly complex industry, livestock are feed scientifically

Table 3. World Imports of Plant Proteins in the Form of Wheat, Coarse Grains 1/ and Oilseed Meal by Economic Groupings of Countries, Average 1964/65-1968/69 2/

	Gross World Imports			World Imports in Terms of Protein Equivalent 4/		
	Wheat & Flour	Coarse Grains	Oilseed Meal 3/	Wheat & Flour	Coarse Grains	Oilseed Meal
	-	thousand metric tons				-
Developed Countries						
EEC (excl. intra-trade)	3,760	13,103	8,248	478	1,310	3,712
United Kingdom	4,337	4,099	1,488	551	410	670
Spain		2,592	702		259	316
Other Europe	2,427	3,717	2,570	308	372	1,156
Japan	3,914	6,877	2,398	497	688	1,079
Canada		634	563		63	253
United States		269	146		27	66
South Africa	292		-	32		-
Oceania	207		40	26		18
Total	14,897	31,291	16,155	1,892	3,129	7,270
Developing Countries						
North & Central America	827	626	172	105	63	77
South America	4,642		50	590		23
Africa	5,008	647	102	636	65	46
Asia	12,717	1,632	789	1,615	163	355
India		(896)				
Total	23,194	2,905	1,113	2,946	291	501
Centrally Planned Countries						
Eastern Europe	4,794	1,233	934	609	123	420
U.S.S.R.	3,641		45	462		20
Mainland China	4,843	67	6	615	7	3
Cuba	647	203	10	82	20	5
Total	13,925	1,503	995	1,768	150	448
World Total	52,016	35,699	18,263	6,606	3,570	8,219

1/ Rye, barley, oats, corn, sorghum and millets
2/ Oilseed cake and meal, Average 1965/69.
3/ Wheat and flour 12%, Coarse grains 10%, Oilseed meal 45%.
4/ Includes imports of oilseeds in terms of oilseed meals.

Source: World Wheat Statistics, 1971, IWC London.
World Grain Trade Statistics, 1969/70, FAO, Rome.
Trade Yearbook, 1970, FAO, Rome.

formulated balanced rations that contain the necessary quantities and proportion of amino acids, vitamins, minerals, energy and bulk. Because different types of livestock, and even the same animals at different stages of growth, require different feed formulations, mixed feed industries have developed for the purpose of producing concentrate feed rations to meet the exacting nutrient requirements of the various types and ages of livestock. In the economically advanced regions that have highly developed commercial livestock feeding industries, the major portion of world consumption of oilseed meals occurs.

Livestock feeding enterprises based on formula feeding of pre-mixed concentrate feeds are largely limited to Western Europe, North America and Japan. In 1965, nearly 95 per cent of world production of mixed feeds was produced in these regions. The United States alone produced 52 per cent of the world total in 1965 and 68 per cent in 1957. Western Europe produced 37 per cent of the total in 1965, while Japan produced 7 per cent, as compared with 28 per cent and 2 per cent, respectively, in 1957.

World trade in mixed livestock feed is not large -- partly because feed specifications vary in different countries and regions. In addition, each consuming region will have certain feed components available from domestic production, and will import additional ingredients to complement domestic production. It is advantageous for feed deficit regions to purchase feed ingredients on the world market and then formulate concentrate feeds to meet domestic requirements. Thus, the major trade in feed-stuffs is

in such ingredient commodities as coarse grains, oilseed meals, and protein supplements from such sources as fishmeal and milling byproducts. The practice of mixing purchased protein concentrates with home-grown grains to provide balanced rations to meet their specific feeding needs is also followed by many livestock feeders in the above developed countries.

During the period 1964/65 to 1968/69, the developed countries provided a market for about 88 per cent of world exports of both coarse grains and oilseed meals. The principal importer was the EEC which accounted for 36 per cent of imports of coarse grains and 45 per cent of oilseed meal imports. Japan imported 19 per cent of the coarse grains entering international trade and accounted for 13 per cent of the imports of meal. However, Japan obtains most of her oilseed meal by crushing imported oilseeds. The United Kingdom was the destination of 11 per cent of total exports of coarse grains and 7 per cent of oilseed meals. The ratio of imports of oilseed meal to the quantity of grains used in livestock feeding was approximately 1:7 in both the EEC and the U.K. More than double the quantities of protein were provided to the developed countries by imports of oilseeds and oilseed meals than by imports of coarse grains.

The developing countries provided a market for 8 per cent of world exports of coarse grains and 6.2 per cent of exports of oilseed meal. The centrally planned countries accounted for 4 per cent of the world market for coarse grain and 5 per cent of the imports of oilseed meal.

Future World Protein Requirements

An important consideration in relation to future food requirements is the level and composition of the average diet of various sections of the population and the factors tending to alter that dietary composition in the period under review. An FAO study of the relative importance of the various food groups in the average diet, using country food balance sheets for the 1964-66 period, was based on a so-called average diet consisting of a total of 2,374 calories, 65.6 grammes of protein and 55.0 grammes of fats. This study shows that cereals, pulses, nuts and oilseeds provide 62.8 per cent of the calories and 59.4 per cent of the protein in the average diet (Table 4). Wheat and rice alone accounted for 37.9 per cent of the calories and 33.3 per cent of the protein. Animal products were the source of 31.7 per cent of the protein intake.

The Demand for Foods

A third in a series of projection studies prepared by FAO, which has recently been published under the title, Agricultural Commodity Projections, 1970-1980, has prepared estimates of the world demand and supply of proteins in 1980[2]. These projections indicate that between 1970 and 1980 the total food demand of the developing countries and the Asian centrally planned countries would rise by 42 and 34 per cent, respectively, and that of high-income countries by 19 per cent (Table 5). On a world basis, this increase

2/ "Agricultural Commodity Projections, 1970-1980, Volume 1", Food and Agriculture Organization of the United Nations, Rome, 1971.

Table 4 - Relative importance of various food groups in average world daily per capita intake, 1964-66.

	Calories		Proteins		Fats	
	Number	Percent	Grammes	Percent	Grammes	Percent
Cereals	1,245	52.4	31.1	47.4	5.1	9.3
Wheat	441	18.6	13.3	20.3	1.5	2.7
Rice	459	19.3	8.5	13.0	1.0	1.8
Maize	147	6.2	3.6	5.5	1.0	1.8
Millet and sorghum	119	5.0	3.5	5.3	1.2	2.2
Others	76	3.2	2.1	3.2	0.4	0.7
Roots and tubers	184	7.8	2.8	4.3	0.4	0.7
Sugar and sugar products	210	8.8	0.1	0.2	-	-
Pulses, nuts and oilseeds	121	5.1	7.9	12.0	3.6	6.5
Vegetables	36	1.5	2.2	3.4	0.3	0.5
Fruits	47	2.0	0.6	0.9	0.3	0.5
Total, Animal products	322	13.6	20.7	31.5	22.4	40.8
Meat	168	7.1	9.2	14.0	14.3	26.0
Eggs	18	0.8	1.4	2.1	1.3	2.4
Fish	19	0.8	3.0	4.6	0.6	1.1
Milk	117	4.9	7.1	10.8	6.2	11.3
Fats and oils	199	8.4	0.1	0.2	22.5	40.9
Vegetable oils	127	5.3	-	-	14.4	26.2
Animal fats	72	3.1	0.1	0.2	8.1	14.7
Total	2,374	100.0	65.6	100.0	55.0	100.0
Animal origin	396	16.7	20.8	31.7	30.5	55.5

Source: FAO Agricultural Commodity Projections, 1970-1980, p. 49.

Table 5 - Projected total demand for selected foods, 1970 to 1980

	Indices				Rates of Growth 1970 to 1980			
	World	High-income countries	Developing countries	Asian centrally planned economies	World	High-income countries	Developing countries	Asian centrally planned economies
	-- 1970 = 100 --				-- Percent per year, compound --			
Total food (farm value)	127	119	142	134	2.5	1.7	3.6	3.0
Calories	127	113	138	130	2.4	1.2	3.3	2.6
Proteins	127	114	138	130	2.4	1.4	3.3	2.7
Animal proteins	131	123	150	144	2.8	2.0	4.1	3.7
Fats	130	112	145	131	2.7	1.2	3.8	3.5
Cereals	125	102	135	128	2.2	0.2	3.0	2.5
Wheat	119	102	138	131	1.8	0.2	3.3	2.8
Rice	130	105	135	127	2.7	0.5	3.0	2.4
Coarse grains	124	98	131	126	2.2	-0.2	2.7	2.3
Pulses, nuts and oilseeds	132	114	138	128	2.8	1.3	3.2	2.5
Meat	135	129	148	146	3.1	2.6	4.0	3.9
Beef and veal	134	131	140	148	3.0	2.8	3.5	4.0
Mutton and lamb	138	126	156	141	3.3	2.4	4.6	3.5
Pigmeat	130	120	154	148	2.7	1.8	4.4	4.0
Poultry meat	149	145	171	146	4.0	3.8	5.5	3.8
Eggs	130	121	156	145	2.6	1.9	4.6	3.8
Whole milk	123	114	150	143	2.1	1.3	4.2	3.7
Skim milk	128	116	148	141	2.5	1.5	4.0	3.5
Cheese	135	131	146	141	3.1	2.7	3.8	3.5
Fats and oils	130	119	149	149	2.7	1.7	4.1	4.0
Butter	123	115	146	141	2.1	1.4	3.9	3.5
Vegetable oils	135	123	150	152	3.0	2.1	4.1	4.2
Animal fats	119	111	147	141	1.8	1.0	4.0	3.5

Source: Agricultural Commodity Projection 1970 - 1980, Volume 1, p. 25. FAO, Rome, 1971.

represents an over-all average annual growth rate of 2.5 per cent. The rate of growth in food consumption for developing countries, which is estimated at 3.6 per cent, is about double the 1.7 per cent growth expected in the high income countries.

Reflecting a more rapid growth in the demand for animal proteins, which is projected to increase by 31 per cent, world food demand is expected to shift progressively to a diet based more on livestock and fisheries products and on fruit and vegetables. Given increasing incomes, this shift will be particularly pronounced in the developing countries, whose diets are based largely on cereals and starchy foods, and where growth in demand for most meats is projected at over 4 per cent per year (Table 5).

Future Trade in Coarse Grains

The availability of supplies to meet the projected consumption increases in 1980 will be dependent in large part on increased indigenous production for many commodities. This is illustrated by changes in the projected ratio of trade to production for a number of selected products between 1964/66 and 1980 (Table 6). This table indicates that the proportion of total production which is exported is projected to decline in the case of wheat, rice, sugar and citrus fruit. The products for which external markets are expected to become more important are meats and feeding stuffs used in livestock production.

Taking into account the expected increase in the proportion of production which will be produced domestically, the FAO study provides estimates of the increase in the volume of selected

products moving in international trade in 1980 as compared with that in 1970 (Table 7). Of particular interest is the optimistic estimated "possible" increase between 1970 and 1980 in imports of coarse grains amounting to 30.7 million tons and oilcake at 5.5 million tons.

Table 6 - Changes in the Export Trade in Selected Farm Products expressed as a percentage of world production, Average 1964-66 and 1980

Commodity	Percentage of Production Exported: Average 1964-66	1980
	%	%
Wheat	21.0	12.2
Rice	5.4	4.1
Sugar	28.0	25.0
Citrus fruit	21.1	19.0
Coarse grains	8.5	10.9
Fats and oils	21.7	23.8
Beef and veal	7.9	9.0
Mutton and Lamb	11.1	16.1
Wine	7.6	11.2

Source: Agricultural Commodity Projections, 1970-1980 Vol. 1, p. 67

Table 7 - Projected Increase in Volume of World Trade in Beef and Veal and in Livestock Feeding Stuffs, 1980 as compared with 1970

Commodity	Projected Increase in Exports 1980 over 1970
	(million tons)
Beef and veal	1.6
Oilcake	5.5
Coarse grains	30.7

Source: Agricultural Commodity Projections, 1970-1980, Vol. 1, p. 66

A study of growth in world demand for coarse grains related to meat and livestock products and human consumption of grain conducted by the Economic Research Service, United States Department of Agriculture, uses a somewhat different approach in preparing its estimates of world grain utilization and trade in 1980[3]. This report indicates that coarse grains constitute about 90 per cent of grain fed to livestock in all countries but represent a declining proportion of food grain, as countries pass through the progressive stages of economic growth. It forecasts that world grain consumption by livestock may reach 515 million tons in 1980, up 62 per cent from the 317 million tons estimated to have been fed to livestock in 1965 and representing an average growth of over 4 per cent annually. Less developed countries are expected to feed their livestock 65 million tons of grain in 1980, centrally planned countries, 150 million tons, and developed countries, over 300 million tons. These figures imply more than doubling the use of feed grain in less developed countries, 65 per cent expansion in centrally planned countries, and 51 per cent in developed countries.

Food is expected to account for about 590 million tons of all grains, with 305 million in less developed countries, 227 million in centrally planned countries, and 58 million in developed countries. This prospect for 1980 is based on the expectation of a 47 per cent growth in less developed countries and a 27 per cent expansion in

3/ "Growth in World Demand for Feed Grains, 1980", Foreign Agricultural Economics Report, No. 63, Economic Research Service, United States Department of Agriculture, Washington, D.C., 1970.

centrally planned countries, offset in part by an 8 per cent decline in developed countries. The 1980 consumption of coarse grains as food is expected to reach 166 million tons. The expected consumption of 96 million tons by less developed countries would be up 55 per cent over the base period. The 60 million ton consumption of centrally planned countries would be up 28 per cent, while the developed countries' 9 million tons should change little. Other uses together may account for 225 million tons of grain in 1980.

This projection, then, provides estimates of 1980 world feed grain consumption ranging from 400 million to 600 million tons in accordance with alternative assumptions. If this projection is borne out and if conditional trends of production materialize, Western Europe and Japan are expected to continue to lead the world in coarse grain imports. The European Community (EEC) is expected to continue importing at about the present rate of 13 million tons, though slight deviation from projected meat demand could cause EEC imports of coarse grains to double by 1980. Japan is likely to at least double its import of coarse grains to over 10 million tons.

From a net export position of 5 million tons in 1965, the less developed countries as a group appear destined to become net importers of at least this amount if present per capita levels of meat consumption are not to be reduced.

To summarize both the FAO projections and those prepared in the U.S.D.A. agree that as a result of the strong tendency toward a greater amount of meat and other animal products in the diet, an increase in the consumption of coarse grains is to be expected by 1980. The interpretation of the implications of the projected

increased consumption of coarse grains in terms of changes in the volume of trade in these products is also reasonably similar. The FAO study suggests a "possible" increase in imports of coarse grains at 30.7 million tons. The U.S.D.A. study suggests that EEC imports of coarse grains in 1980 will likely continue at about 13 million tons and those of the rest of Western Europe at the 8 million ton level, but both might double to 26 and 16 million tons, respectively.

Japan is expected to double its current level of imports of coarse grains to amount to over 10 million tons. This study also suggests the possibility that the developing countries may shift from having 5 million tons net exports to importing 5 million tons of coarse grains, representing a possible shift of 10 million tons.

Projected Demand and Supply for Oilcakes and Meals

The comprehensive review of the longer-term outlook for the demand, production and trade in oilcakes and meals prepared by FAO as part of the Agricultural Commodity Projections, 1970-1980, has been drawn on extensively in this paper. The FAO survey indicates that the last decade has been a period of relatively steady expansion in the world oilseeds, oils and fats economy. Effective demand for oilcakes has been growing much faster than for fats and oils. This has resulted in a stronger price trend for oilcakes than for fats and oils and has also favored products with a high cake and low oil content, in particular soybeans and fish for processing. Developed countries, especially the United States, have expanded their share of both production and trade in fats and oils and particularly oilcakes. Production in developing regions has risen only moderately and, with

increasing domestic consumption of fats and oils, exports have not increased fast enough to maintain the previously held share of world trade. The U.S.S.R. and Eastern Europe have become more important in world trade, especially in fats and oils, mainly through increased exports of sunflower seed and oil.

World production of fats and oils rose by an average of about 1 million tons a year during the sixties, equal to an annual increase of 2.6 per cent.

Output of those oils derived from seeds grew considerably faster than non-seed oils and fats with the result that production of oilcakes and meals (the other joint-product of crushing oilseeds) grew at 4.9 per cent a year, nearly double the rate of fats and oils, World production in 1970 is estimated at over 57 million tons. Among individual products, soybean meal output rose rapidly, increasing its share of the total output from about 45 per cent at the beginning of the decade to over 50 per cent in the last three years. Production of fishmeal rose even faster and now accounts for almost 10 per cent of total output. The growing importance of soybean cake and also of rapeseed cake has meant that the developed countries now produce over half the world's supplies. The share of centrally planned economies in the production of oilcakes and meals has fallen in spite of a bigger share in world output of fats and oils; this is partly due to the introduction of new varieties of sunflower seed which, in addition to higher yields per unit of area, have a relatively higher content of oil and a lower content of cake.

Utilization of oilcakes has risen sharply, from about 35 million tons at the beginning of the decade to over 58 million tons at the end of it. Consumption remains heavily concentrated in the developed and, to a lesser extent, centrally planned regions. The rapid growth of output of poultry in Europe, the general expansion of livestock production in Japan and the development of more intensive feeding methods for most types of livestock have all contributed to the rapid increase in demand.

Trade in both fats and oils and in oilcakes has been growing faster than production, the increase over the last ten years averaging some 3.8 pèr cent per year for fats and oils and about 8.0 per cent for oilcakes. In the last few years the volume of fats and oils exported averaged over 12 million tons and amounted to almost one-third of total production; for oilcakes and meals, the comparable importance of trade is even higher, exports being over 45 per cent of total output. The value of exports in 1970 amounted to U.S.$4,200 million for oilcakes and meals.

The development of trade in oilcakes is dominated by the rapidly increasing importance of soybean cake exports, mainly from the United States. Soybean cake now accounts for about half of the total trade in oilcakes as against a third at the beginning of the decade. Fishmeal exports have also grown rapidly, but generally the exports of developing countries in other oilcakes have lost ground, reflecting a slow growth in output.

The FAO projections suggest that world consumption of oilcakes and meals will amount to 71.4 million tons in 1980 as compared with 45 million tons in 1965 and 58 million in 1970 (Table 8). It was also indicated that in 1980 some 60 per cent

Table 8 - Oilcakes and meals: Production, consumption and balances, 1964-66 average, 1970+ and projections for 1980

	1964-66 average			1970+			1980		
	Pro-duction	Net trade (exports (-))	Con-sumption	Pro-duction	Balance (exports (-))	Con-sumption	Pro-duction	Balance (exports (-))	Demand
	(.	. . . .	. . . .	Thousand tons	. . . .	. . . .	. . . .	. . . .	. . . .)
WORLD	45 500	- 134	45 394	57 633	-1 246	58 578	74 833	-3 411	71 422
ECONOMIC CLASS I	21 896	6 667	28 517	29 862	4 901	37 356	38 637	4 825	43 462
North America	19 554	-6 770	12 785	26 769	-13 285	16 139	34 704	-17 704	17 000
United States	18 823	-6 607	12 216	25 719	-13 104	15 315	32 832	-16 832	16 000
Western Europe	1 502	11 642	13 097	1 857	15 312	17 107	2 387	18 961	21 348
EEC	380	7 141	7 521	519	10 278	10 797	790	13 279	14 069
Other western Europe	1 122	4 501	5 576	1 338	5 034	6 310	1 597	5 682	7 279
United Kingdom	86	1 905	1 991	91	1 692	1 783	107	2 115	2 222
Oceania	30	43	73	39	57	96	49	221	270
Others	809	1 752	2 561	1 197	2 817	4 014	1 497	3 347	4 844
Japan	427	1 827	2 254	574	3 002	3 576	[illegible]	3 561	4 234
ECONOMIC CLASS II	13 064	-7 097	6 042	15 773	-7 068	8 303	21 117	-9 689	11 428
Africa	2 011	-1 679	332	2 016	-1 628	388	2 946	-2 301	645
Northwestern Africa	40	- 23	17	50	- 37	13	61	- 28	33
Western Africa	1 318	-1 267	51	1 188	-1 104	84	1 865	-1 764	101
Nigeria	714	- 703	11	569	- 556	13	878	- 860	18
Senegal	332	- 322	10	269	- 242	27	497	- 480	17
Central Africa	197	- 146	51	253	- 198	55	306	- 221	85
Eastern Africa	456	- 243	213	525	- 289	236	714	- 290	424
Latin America	4 744	-3 051	1 768	6 584	-3 755	2 427	7 685	-4 135	3 550
Central America	911	- 230	681	958	105	1 063	1 032	364	1 396
Mexico	667	- 83	584	792	163	955	836	382	1 218
Caribbean	36	53	89	39	52	91	55	93	148
South America	3 797	-2 874	998	5 587	-3 912	1 273	6 598	-4 862	2 006
Argentina	925	- 950	47	1 047	- 938	109	1 254	1 090	164
Brazil	822	- 338	484	1 522	- 940	582	2 339	-1 473	866
Peru	1 547	-1 404	143	2 350	-1 868	122	2 106	-1 853	253
Near East	1 468	- 737	731	1 717	- 738	979	2 292	- 877	1 415
Sudan	328	- 313	15	407	- 375	32	533	- 508	25
Turkey	332	- 229	103	486	- 191	295	743	- 393	350
United Arab Republic	452	- 34	418	437	- 23	414	494	144	638
Asia and Far East	4 747	-1 537	3 210	5 355	- 865	4 499	8 045	-2 247	5 798
South Asia	3 609	- 948	2 661	4 202	- 553	3 649	6 310	-1 763	4 547
India	2 979	- 868	2 111	3 441	- 475	2 966	5 258	-1 707	3 551
Pakistan	509	- 50	459	659	- 70	589	902	- 89	813
East and Southeast Asia	1 138	- 589	549	1 153	- 303	850	1 735	- 484	1 251
Indonesia	266	- 216	50	309	- 273	36	356	- 290	66
Philippines	508	- 476	32	389	- 358	31	646	- 599	47
Others	94	- 93	1	101	- 91	10	149	- 129	20
ECONOMIC CLASS III	10 540	296	10 836	11 998	921	12 919	15 079	1 453	16 532
Asian centrally planned economies	5 773	- 485	5 288	6 180	- 445	5 735	7 523	- 495	7 028
China (Mainland)	5 747	- 483	5 264	6 156	- 445	5 711	7 495	- 495	7 000
U.S.S.R. and eastern Europe	4 767	781	5 548	5 818	1 366	7 184	7 556	1 948	9 504
U.S.S.R.	3 965	- 139	3 826	4 744	- 266	4 478	5 855	202	6 057
Eastern Europe	802	920	1 722	1 074	1 632	2 706	1 701	1 746	3 447

Note: In 1964-66 and 1970+, stock changes have been taken into account where possible, but are not shown separately.

Source: Agricultural Commodity Projections, 1970-1980, Vol. 3, p. 165

of world consumption would continue to be in the developed countries. The write-up accompanying the FAO projections indicates many uncertainties with respect to future consumption of oilcakes and meals and the possibility under changed feeding methods that the consumption in 1980 might be as much as 50 per cent higher than the level indicated above.

Production Projections

FAO's projected supply of oilcakes in 1980 which was derived from the projected supply of individual oilseeds (Table 9) shows that projected production would increase by nearly two-thirds, from 45.5 million tons to almost 75 million tons in 1980.

Soybean meal would remain by far the most important individual commodity of the group (Table 9). Together with groundnut cake, the "high-protein content" cakes are expected to provide over 60 per cent of the total protein in all oilcakes and meals. Output of fishmeal, an important competitor with a higher protein content than either soybean or groundnut cake, is projected to grow by only 0.6 per cent a year, from 1970 to 1980, a rate very much slower than the 8.7 per cent achieved in the sixties. Even so, fishmeal would still account for over 10 per cent of total protein supply from all oilcakes and meals.

The group of five "medium protein content" oilcakes are expected to provide over 25 per cent of total protein supplies from oilcakes by 1980, a slight decline from the 1965 level. Relatively fast increases in the output of rapeseed and, to a lesser extent, sunflower cake would only partially offset a slower rise in cottonseed cake output.

Table 9 - Oilcakes and meals: World production by type, 1964-66 average, 1970+ and projections for 1980

	Production			Average rates of growth		Share in total production			Share in total protein content		
	1964-66 average	1970+	1980	1970 to 1980	1964-66 to 1980	1964-66 average	1970+	1980	1964-66 average	1970+	1980
	(. . . Thousand tons . . .)			(Percent per year, compound)		(. . . . . Percent . . . .)					
GRAND TOTAL	45 501	57 631	74 822	2.6	3.4	100.0	100.0	100.0	100.0	100.0	100.0
By commodities											
FISH MEAL	3 784	5 309	5 646	0.6	2.7	8.3	9.2	7.5	12.1	13.2	10.9
VEGETABLE OILCAKES	41 717	52 322	69 176	2.8	3.4	91.7	90.8	92.5	87.9	86.8	89.1
High-protein content											
Groundnut cake	3 955	4 261	6 211	3.8	3.1	8.7	7.4	8.3	9.8	8.2	9.3
Soybean cake	19 351	27 699	36 636	2.8	4.3	42.5	48.0	49.0	44.9	56.1	51.5
Medium-protein content											
Cottonseed cake	8 578	9 024	10 749	1.8	1.5	18.9	15.6	14.3	17.7	14.5	13.4
Sesameseed cake	674	725	865	1.8	1.7	1.5	1.3	1.2	1.3	1.1	1.0
Sunflowerseed cake	3 113	3 956	5 480	3.3	3.8	6.8	6.9	7.3	4.8	4.8	5.2
Linseed cake	1 713	1 818	1 806	-	0.4	3.8	3.2	2.4	3.1	2.5	2.0
Rapeseed cake	2 633	3 218	5 015	4.2	4.4	5.8	5.6	6.7	4.5	4.3	5.2
Low-protein content											
Copra cake	1 196	1 102	1 545	3.4	1.7	2.6	1.9	2.1	1.3	0.9	1.0
Palm kernel cake	504	519	869	5.3	3.7	1.1	0.9	1.2	0.5	0.4	0.5
By economic classes											
Economic Class I	21 902	29 862	38 634	2.6	3.9	48.1	51.8	51.6	50.9	54.2	54.2
Economic Class II	13 059	15 771	21 113	3.0	3.2	28.7	27.4	28.2	27.7	26.9	27.4
Economic Class III	10 540	11 998	15 075	2.3	2.4	23.2	20.8	20.2	21.4	18.9	18.4
TOTAL PROTEIN CONTENT	19 389	24 902	32 017	2.5	3.4	-	-	-	100.0	100.0	100.0

Source: Agricultural Commodity Projections, 1970-1980, Vol. 3, p.

The "low-protein content" cakes - copra and palm kernel cake - would remain relatively unimportant. By 1980, they are projected to account for no more than 3.3 per cent of product weight and 1.5 per cent of protein content of all oilcakes. The output of palm kernel cake is projected to rise rapidly during the seventies, due to the expansion in oil palm area but would not compensate for the falling share of the more important copra cake.

A study of world supply and demand prospects for oilseeds and oilseed products in 1980 carried out by the Economic Research Service, U.S. Department of Agriculture, project world oilcake production to increase by an annual rate of 3.4 per cent during 1963-65 through 1980. World consumption in 1980 is projected at 66 million tons as compared with an average of 39.3 million tons in the 1963-65 period (Table 8). As a result of varying rates of growth in different developed countries, a higher proportion of consumption of oilcake in 1980 will occur in the EEC and other Western European countries as well as in Japan.

Future Trade in Oilcakes and Meals

In addition to the 8 million tons of oilseed meals imported on the average during the period 1965-69, the equivalent of 9.2 million tons of meal was imported in the form of seed and crushed in the importing country (Table 11). This means that a total of over 18 million tons oilseed meals equivalent have been imported annually on an average during these years. Many countries, including Japan, Spain, Canada and the developing countries in South America, Africa and Asia obtain most of their imported

Table 10. World Oilseed Consumption, 1963-65 average, and Demand Projections to 1980

Region	1963-65 consumption	Percentage of World Total	Projected 1980 consumption	Percentage of World Total	Percentage Increase	Annual Growth Rate
	1,000 metric tons	Percent	1,000 metric tons	Percent	Percent	Percent
U.S.	11,812	31.1	15,180	23.0	23.5	1.6
Canada	880	2.2	1,314	2.0	49.1	2.5
EC	5,249	13.4	10,429	15.8	95.7	4.4
UK	1,619	4.1	3,190	4.8	97.0	4.3
OWE	2,479	6.3	5,074	7.7	105.3	4.6
Japan	1,915	4.8	4,866	7.4	156.8	6.0
Australia, N.Zealand, & S.Africa	119	0.3	215	0.3	80.7	3.8
Total	24,575	62.2	40,268	61.0	66.9	3.2
E. Europe	1,623	4.1	3,024	4.6	86.3	4.0
USSR	3,768	9.5	6,348	9.6	68.5	3.3
Communist Asia	3,333	8.4	4,507	6.8	35.2	1.9
Total	8,724	22.0	13,879	21.0	59.1	3.0
Mexico, Central & South America	1,136	2.9	1,870	2.8	64.5	3.2
East, West, N.Africa & W. Asia	833	2.1	1,335	2.0	60.3	3.0
S.SE, East Asia & Pac.Is.	4,254	10.8	8,733	13.2	105.3	4.6
Total	6,223	15.8	11,938	18.0	91.8	4.1
World Total	39,522	100.0	66,085	100.0	67.2	3.3

Source: World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, Foreign Agricultural Economic Report No. 71, Economic Research Service, USDA Washington, D.C. 1971.

supplies of oilseed meal in the form of seed. The EEC countries which account for 45 per cent of the combined imports of oilseed meals, obtain 45 per cent of their total imported meals in the form of seed. The FAO projections of the demand and supply of oilseed meals imply an increased volume of trade. Projected import requirements in 1980 are expected to be about 76 per cent higher than 1965 and 26 per cent above 1970, with the United States continuing to be the main supplier. Canada is expected to increase in importance as an exporter.

The trade implications of projected changes in the demand for oilcakes as presented in the U.S.D.A. study are shown in Table 12 according to regions and countries. Total world trade in oilmeals is expected to expand to 23.5 million metric tons by 1980 as compared with the 11.6 million ton average for the 1963/65 base period. Almost all of the increases in imports are expected to occur in the economically developed countries, with the result that about 96 per cent of the market for oilmeals in 1980 will be in Europe and Japan. The EEC is expected to provide a market for 9.6 million tons of oilmeals or 41 per cent of total oilmeals exported. Japan is expected to import 4.9 million tons followed by the United Kingdom with 3.2 million tons and other West European countries totalling 4.6 million tons. The United States is expected to be the source of over 70 per cent of the oilmeals exported, most of the balance coming from developing countries in Latin America and Africa and Asia. It should be noted that these calculations do not take into account the recent expansion in Canada in the production and export of rapeseed and its products.

Table 11. World Imports of oilseed Meals and Oilseeds in Terms of Meal1/, Average 1965-69

	Seeds in terms of meal	Oilseed meal	Total
	- thousand metric tons -		
Developed Countries			
EEC (incl. intra-trade)	3,558	4,690	8,248
United Kingdom	469	1,019	1,488
Spain	628	74	702
Other Western Europe	744	1,826	2,570
Japan	2,239	159	2,398
Canada	347	216	563
United States	146	-	146
South Africa	-	-	-
Oceania	18	22	40
Total	8,149	8,006	16,155
Developing Countries			
North and Central America	29	143	172
South America	43	7	50
Africa	62	40	102
Asia	638	151	789
India			
Total	772	341	1,113
Centrally Planned Countries			
Eastern Europe	240	694	934
U.S.S.R.	45	-	45
Mainland China	6	-	6
Cuba	10	-	10
Total	301	694	995
World total	9,222	9,041	18,263

1/ Copra (35%), soybean (79%), linseed (64%), cottonseed (69%), rapeseed (57%), sesame (52%), sunflower (37%), groundnuts (56%), palm kernels (52%).

Source: Trade Yearbook 1970, FAO, Rome.

Table 12. Oilcakes: World Supply and Trade, by Region, Average 1963/65 and Projected to 1980

	Average 1963/65				1980				Share of 1980 trade	
	Supply	Demand	Export	Import	Supply	Demand	Export	Import	Import	Export
	- 1,000 metric tons -				- 1,000 metric tons -				- per cent -	
Developed										
United States	18,198	11,812	5,904	-	31,820	15,180	16,640	-	-	70.9
Canada	500	880	-	380	949	1,314	-	365	1.6	-
EEC	262	5,269	-	5,007	742	10,429	-	9,687	41.2	-
United Kingdom	-	1,619	-	1,619	-	3,190	-	3,190	13.6	-
Other Western Europe	289	2,479	-	2,190	454	5,074	-	4,620	19.7	-
Japan	70	1,915	-	1,845	-	4,866	-	4,866	21.7	-
Australia, New Zealand and South Africa	139	119	20	-	245	215	30	-	-	.1
Total	19,458	24,575	5,924	11,041	34,210	40,268	16,670	22,728	96.8	71.0
Centrally Planned										
Eastern Europe	1,045	1,623	-	578	2,269	3,024	-	755	3.2	-
USSR	3,897	3,768	129	-	6,398	6,348	50	-	-	.2
Communist Asia	3,415	3,333	82	-	4,957	4,507	450	-	-	1.9
Total	8,357	8,724	211	578	13,624	13,879	500	755	3.2	2.1
Developing										
Latin America	2,574	1,136	1,438	-	4,366	1,870	2,496	-	-	10.6
Africa & West Asia	2,801	833	1,968	-	4,805	1,335	3,470	-	-	14.8
Other Asia	5,416	4,254	1,162	-	9,080	8,733	347	-	-	1.5
Total	10,791	6,223	4,568	-	18,251	11,938	6,313	-	-	26.9
World Total	38,606	39,522	10,703	11,619	66,085	66,086	23,483	23,483	100.0	100.0

Source: World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, Foreign Agricultural Economic Report No. 71, Economic Research Service, USDA, Washington, December 1971, p. 120.

Selected Countries as Markets for Protein Feeds

Each market for protein feeds has its own particular characteristics which require special consideration. The average production, imports, exports and domestic use of oilseed meals for the period 1965/69 and for 1970 for the principal importing countries are presented in Table 13.

The type of oilcake consumed in a region depends largely on the type that is produced in that area or are available. Some countries have preferences for a particular type of oilcake (e.g. the Netherlands are said to prefer linseed meal in most compound feeds). However, in general, the cake utilized is the one which can meet the nutritional requirements at the lowest price.

The six EEC countries are treated as a group from the standpoint of trade; since they have common import regulations, apart from the limited use of compensatory border taxes to adjust for deterioration of exchange rates. The domestic use of oilseed meals reached 10 million tons in 1970. Of this amount, 6.1 million tons were imported in the form of meal and most of the meal from domestic crushings came from imported beans.

Soybean meal accounts for about two-thirds of EEC consumption of oilseed meals. Linseed meal, groundnut meal and copra meal followed in fairly close order of importance but substantial quantities of all of the other types of meal are also imported regularly. Fishmeal is an important competitor with oilseed meals.

Denmark and Spain each use almost 1 million tons of oilseed meals. Over half of Denmark's consumption is from soybeans with cottonseed meal second in importance. Nearly all of Spain's consumption of meal is soybeans.

Table 13. Total Supplies of Oilseed Meals Available for Domestic Consumption, Western Europe and Japan, Average 1965-69, Annual 1970.

	Production	Imports	Exports	Domestic Use
	-- thousand metric tons --			
E.E.C.				
Average 1965-69	3,784	4,635	916	7,503
1970 p.	5,127	6,100	1,189	10,038
Denmark				
Average 1965-69	342	803	150	995
1970 p.	381	718	116	983
Spain				
Average 1965-69	716	101	8	809
1970 p.	1,112	36	-	1,148
United Kingdom				
Average 1965-69	422	1,020	44	1,398
1970 p.	358	989	24	1,323
Other West Europe				
Average 1965-69	565	865	53	1,377
1970 p.	631	947	107	1,471
Total West Europe				
Average 1965-69	5,830	7,423	1,171	12,082
1970 p.	7,652	8,854	1,482	15,024
Japan				
Average 1965-69	2,411	97	10	2,498
1970 p.	3,296	90	-	3,386

Source: Oil World, 1971.

The United Kingdom uses 1.3 million tons of oilseed meal, more than two-thirds of which is imported as meal and the balance is from domestic crushings of imported seed. Somewhat less than half of the meal used in the U.K. is from groundnuts, followed by soybeans and cottonseed. Considerable quantities of fishmeal are also used.

Other Western European countries jointly use an average of 1.4 million tons of oilseed meal, mostly from soybeans. About 25 per cent of their oilseed meal is from domestic crushings of imported seed. Cottonseed and groundnut seed were were second and third in importance but substantial quantities of all oilseed meals are imported.

Japan is a fast growing consumer of oilseed meal, nearly all of which is derived from domestic crushings of imported seed. About 75 per cent of Japan's supplies are soybeans. However, considerable quantities of all other oilseeds are imported, with an increasing dependence on rapeseed. Fishmeal is also an important source of feed protein in Japan.

The projected position of each exporting and importing country with respect to their level of export availability and import requirements of oilseed meals in 1970 and 1980, as compared with average exports and imports in the period 1964/66, is presented in Table 14. This suggests that the EEC countries will provide a market for half of the exports, followed by Japan with 13 per cent and the United Kingdom with 8 per cent. The United States is expected to supply 56 per cent of the exports followed by Peru, the principal source of fishmeal.

Table 14 Oilcakes and meals: International trade, 1964-66 average, 1970+ and production/demand balances for 1980.

	Net exports 1964-66 average	Implied export availability		Net imports 1964-66 average	Implied import requirement		Net exports 1964-66 average	Implied export availability		Net imports 1964-66 average	Implied import requirement	
		1970+	1980		1970+	1980		1970+	1980		1970+	1980
	(. . . . . Thousand tons					. . . .)	(. . . . . . . Percent of world trade					. . . .)
WORLD	15 375	22 512	30 258	15 241	21 266	26 847	100.0	100.0	100.0	100.0	100.0	100.0
ECONOMIC CLASS I	7 193	13 824	18 448	13 860	18 725	23 273	46.8	61.5	61.0	90.9	88.0	86.7
North America	6 770	13 285	17 704	-	-	-	44.0	59.1	58.5	-	-	-
Western Europe	150	119	252	11 792	15 431	19 213	1.0	0.6	0.8	77.3	72.5	71.6
EEC	-	-	-	7 141	10 278	13 279	-	-	-	46.8	48.3	49.5
Other western Europe	150	119	252	4 651	5 153	5 934	1.0	0.6	0.8	30.5	24.2	22.1
Oceania	-	-	-	43	57	221	-	-	-	0.3	0.3	0.8
Others	273	420	492	2 025	3 237	3 839	1.8	1.9	1.6	13.3	15.2	14.3
ECONOMIC CLASS II	7 547	7 938	11 302	450	870	1 613	49.1	35.3	37.4	3.0	4.1	6.0
Africa	1 704	1 641	2 362	25	13	61	11.1	7.3	7.8	0.2	0.1	0.2
Latin America	3 193	4 084	4 774	142	329	639	20.8	18.1	15.0	0.9	1.5	2.4
Near East	773	779	1 124	36	41	247	5.0	3.5	3.7	0.2	0.2	0.9
Asia and Far East	1 784	1 343	2 913	247	487	666	11.6	6.0	9.6	1.7	2.3	2.5
Others	93	91	129	-	-	-	0.6	0.4	0.4	-	-	-
ECONOMIC CLASS III	635	750	508	931	1 671	1 961	4.1	3.3	1.7	6.1	7.9	7.3
Asian centrally planned economies	485	445	495	-	-	-	3.1	2.0	1.7	-	-	-
U.S.S.R. and eastern Europe	150	305	13	931	1 671	1 961	1.0	1.3	-	6.1	7.9	7.3
PRINCIPAL EXPORTERS	12 900	19 902	27 261	-	-	-	83.9	88.4	90.1	-	-	-
United States	6 607	13 140	16 832	-	-	-	43.0	58.2	55.6	-	-	-
Peru	1 404	1 868	1 853	-	-	-	9.1	8.3	6.1	-	-	-
Argentina	950	938	1 090	-	-	-	6.2	4.1	3.6	-	-	-
India	868	475	1 707	-	-	-	5.6	2.1	5.6	-	-	-
Nigeria	703	556	860	-	-	-	4.6	2.4	2.8	-	-	-
China (Mainland)	483	445	495	-	-	-	3.1	2.0	1.6	-	-	-
Philippines	476	358	599	-	-	-	3.1	1.6	2.0	-	-	-
Brazil	338	940	1 473	-	-	-	2.2	4.2	4.9	-	-	-
Senegal	322	242	480	-	-	-	2.1	1.1	1.6	-	-	-
Sudan	313	375	508	-	-	-	2.0	1.7	1.7	-	-	-
South Africa	273	420	492	-	-	-	1.8	1.9	1.6	-	-	-
Canada	163	181	872	-	-	-	1.1	0.8	2.9	-	-	-
PRINCIPAL IMPORTERS	-	-	-	13 341	18 723	23 394	-	-	-	87.5	88.0	87.1
EEC	-	-	-	7 141	10 278	13 279	-	-	-	46.8	48.3	49.5
United Kingdom	-	-	-	1 905	1 692	2 115	-	-	-	12.5	8.0	7.8
Japan	-	-	-	1 827	3 002	3 561	-	-	-	12.0	14.1	13.3
Denmark	-	-	-	978	860	644	-	-	-	6.4	4.0	2.4
Spain	-	-	-	519	1 317	1 614	-	-	-	3.4	6.2	6.0
Czechoslovakia	-	-	-	317	460	560	-	-	-	2.1	2.2	2.1
Hungary	-	-	-	254	436	584	-	-	-	1.7	2.0	2.2
Israel	-	-	-	198	235	278	-	-	-	1.3	1.1	1.0
China (Taiwan)	-	-	-	119	280	377	-	-	-	0.8	1.3	1.4
Mexico	-	-	-	83	163	382	-	-	-	0.5	0.8	1.4

Source: Agricultural Commodity Projections, 1970-1980, Vol. 1, FAO, Rome, p. 168

Canadian Supply and Utilization of Feed Proteins

On the basis of the average for the period 1964/65 to 1968/69, Canada's domestic use of grains in livestock feeding amounted to 15.7 million tons out of a total production of all grains (including wheat) amounting to 36.8 million tons (Table 15). The principal sources of feed grains consumed are oats, accounting for 36 per cent, and barley, making up 25 per cent. Corn, mixed grains and wheat, each contributed from 10-12 per cent of the grains fed. Expressed in terms of protein equivalent, the total grains fed amounted to about 1.8 million tons of protein, an average of 11.3 per cent of all grains. Oilseed meals fed amounted to 578,000 tons, equivalent to 254,000 tons of protein. This was equivalent of an addition of 1.6 per cent protein to the total volume of grain consumed. Soybean meal was the source of 86 per cent of the oilseed protein supplied. Only 113,000 tons of the 478,000 tons of soybean meal consumed in Canada was from domestically produced seed. The remainder was imported either in the form of beans or meal.

In Table 16 an attempt has been made to make a rough estimate of the protein derived from hay and fodder corn fed and from pasture. Using these estimates, the total amount of protein consumed by livestock would amount to some 6.4 million tons of which 2.0 million is considered to be from pasture. A total of 2.3 million tons of protein would be provided from roughage such as hay and corn fodder for winter feeding. Grain and oilseeds would provide protein supplement to this

Table 15. Supply and Utilization of Grains, Oilseeds and Fodder Crops in Canada, expressed in terms of total volume and protein equivalent, average 1964/65-1968/69

	Production	Imports	Exports	Available for domestic use: Total	Available for domestic use: Feed	Protein equivalent of domestic use: Total	Protein equivalent of domestic use: Feed
	-		thousand short tons				-
Wheat	19,920	-	12,849	4,716	1,651	599	210
Oats	6,081	-	144	6,108	5,680	672	625
Barley	6,058	-	967	4,702	3,950	564	474
Rye	406	-	179	218	122	26	15
Corn	1,870	728	11	2,573	1,930	231	174
Mixed grains	1,780	-	-	1,780	1,780	205	205
Millfeeds	665	-	91	574	574	66	66
Sub-total	36,780	728	14,241	20,671	15,687	2,363	1,769
Soybeans	246	453	69	630			
Soybean meal	476	240	196	478	468	219	219
Flaxseed	563	-	417	157			
Linseed meal	43	-	13	30	30	11	11
Rapeseed	529	-	317	89			
Rapeseed meal	66	-	-	66	66	22	22
Sunflowerseed	15	-	5	10			
Sunflowerseed meal	4	-	-	4	4	2	2
Mustard seed	95	-	50	45			
Sub-total					578	254	254
Dry peas and beans	98	6	43	61	11	5	3
Tame hay (7% protein)	23,485						1,643
Fodder corn (8% protein)	8,500						680
Pasture (1966)	63 million acres						
Improved	11 million acres, 250 lb. protein per acre						1,375
Unimproved	52 million acres, 25 lb. protein per acre						650
Sub-total							2,025
Total							6,374

Source: The Canadian Agricultural Situation, Sept. 1971, CDA; Fats and Oils in Canada, Annual Review, 1969.

aggregate ration in the amount of 2 million tons of protein. While the estimates are very rough, they serve to illustrate the importance of the protein in forage and pasture in livestock feeding.

The growth in the supply of oilseed meals from oilseed crushings in Canada is shown in Table 16. In 1970/71, Canadian crushings produced 728,000 tons of oilseed meal as compared with an average of 588,000 tons during the period 1964/65 to 1968/69. The composition of available supplies of all high protein feeds in Canada in 1970 as compared with 1968 and 1969 is shown in Table 17. The total of 1.4 million tons of high protein feed available in 1970 included 1.1 million tons of vegetable protein, 218,000 tons of which is derived from by-products of the distilling and brewing industry. Of the 312,000 tons of animal protein, 247,000 tons is from packing house by-products, 45,400 tons from fish by-products and 19,800 tons from dairy industry by-products.

Table 16. Oilseed Crushings in Canada, average 1964/65-1968/69, annual 1969/70 and 1970/71

	Average 1964/65-1968/69		1969/70		1970/71	
	Quantity crushed	Oilmeal produced	Quantity crushed	Oilmeal produced	Quantity crushed	Oilmeal produced
	thousand bushels	tons	thousand bushels	tons	thousand bushels	tons
Flaxseed	2,485	42,882	2,490	43,536	2,827	49,782
Rapeseed	4,591	65,740	7,768	114,232	8,469	123,228
Soybeans	19,994	475,868	23,679	558,743	23,437	549,173
Sunflower-seed	665	3,698	708	4,311	1,080	5,977

Source: Oilseeds Review, September 1971.

Table 17. Available Supplies of High Protein Feed in 1970 with Comparative Figures for 1968 and 1969

	1968	1969	1970[1/]
	-	tons	-
Linseed oil meal	29,400	29,500	34,700
Soybean oil meal	535,200	608,500	684,800
Rapeseed oil meal	82,700	107,200	116,200
Malt sprouts, gluten feed, brewers' and distillers' dried grains and other oil meals [2/]	211,560	208,753	218,394
Totals, vegetable protein	858,860	953,953	1,054,094
Fishmeal	69,600	61,900	45,400
Packing house by-products	232,000	255,000	247,000
Skin milk, buttermilk & whey powders	19,600	19,800	19,800
Totals, animal protein	321,200	336,700	312,200
Totals, protein supplies	1,180,000	1,290,653	1,366,294

1/ Preliminary and partly estimated
2/ Other oil meals include sunflower, cotton seed, and n.e.s.
Source: Coarse Grains Review, Dominion Bureau of Statistics, August 1971.

Manufactured Feeds in Canada

There are about 860 establishments in Canada engaged in the manufacture of animal feeds. The value of shipments of manufactured materials is about $500 million and the cost of ingredients and supplies is about $370 million. Each manufacturer produces a variety of branded products, including both complete feeds which average about 2.1 million tons per year and micro-premixes and supplements averaging in terms of complete feed equivalents, about 5.1 million tons (Table 18). These manufactured feeds are classified according to type.

TABLE 18- CANADA - Shipments of Complete Feeds and of Micro-Premixes in terms of Complete Feed Equivalent, 1968-1970.

Type of Feed	Complete Feeds			Micro-Premixes and Supplements[1]		
	1968	1969	1970	1968	1969	1970
	tons	tons	tons	tons	tons	tons
Calf feed	35,300	45,830	36,345	21,829	20,361	24,870
Cattle feed						
- Beef	82,004	73,906	61,558	1,050,662	1,170,929	1,126,993
- Dairy	252,670	261,620	298,430	999,334	1,050,957	1,099,917
Swine feed	342,365	330,107	407,004	1,622,818	1,691,240	2,025,799
Poultry feed	1,174,107	1,260,336	2,071,728	1,040,999	1,145,238	1,288,158
Other	--	19,633	24,632	--	1,633	3,200
Total	1,886,746	1,991,962	2,299,697	4,735,642	5,080,398	5,568,907

1/ Quantities of micro-premixes and supplements expressed in terms of complete feed equivalent.

Source: Shipments of Prepared Stock and Poultry Feeds, Catalogue No. 32-004 Statistics Canada.

The most important is poultry feed which make up 73 per cent of complete feeds and 22 per cent of micro-premixes and supplements. Swine feeds make up 17 per cent and 35 per cent, respectively, of complete feeds and micro-premixes and supplements. Dairy rations account for 10 per cent of complete feeds and 20 per cent of micro-premixes and supplements.

Regulations under the Feeds Act provide for a minimum guaranteed level of protein for each class of feed. There are:

Type of feed	Per cent complete feeds	Protein supplements
Cattle feeds		24
Calves	13	
Cows in milk	15	
Other cattle	13	
Swine feeds	13 - 17	35
Poultry feeds	13 - 22	35

A wide range of ingredients are utilized in the manufacture of livestock feeds (Table 19). These include grains and grain by-products which make up 65 per cent of the ingredients. They are the primary source of energy in the feed but also contribute varying amounts of protein. The additional plant protein for high-protein feeds and for supplements is provided principally by oilcake and oilcake meal and make up about 14 per cent of the total inputs. Animal proteins are contributed by dairy, fish and meat and tankage by-products and make up about 11.5 per cent of ingredients.

Table 19. - Percentage Distribution of Ingredients in Manufactured Feeds in Canada, 1967-1969.

Ingredient	Percentage of Total Value		
	1967	1968	1969
	%	%	%
Grains	(47.6)	(46.1)	(42.9)
Wheat	9.6	8.7	8.1
Barley	12.7	12.6	10.2
Corn	11.9	13.3	11.0
Oats	8.8	7.9	5.3
Rye	0.3	0.2	0.1
Other grains	1.2	0.8	6.1
Screenings, all kinds	3.1	2.6	2.1
Flour and meal edible	0.3	0.4	0.2
Grain by-products	(17.4)	(17.9)	(23.6)
Bran, shorts and middlings	6.1	5.6	4.6
Brewers' and distillers' grains	1.0	1.1	5.5
Cereal meal	0.5	0.7	3.3
Germ of wheat and gluten	0.8	0.7	0.8
Supplements and premixes	9.0	9.8	9.4
Oilcake and oilcake meal	(13.7)	(14.0)	(12.4)
Soybean cake and meal	11.8	11.9	10.4
Linseed cake and meal	0.6	0.6	0.3
Rapeseed cake and meal	1.1	1.2	1.4
Other oil cake and meal	0.2	0.3	0.3
Beet pulp and pomace	0.5	0.6	0.4
Legumes and grasses	1.6	1.7	1.2
Dairy by-products	1.5	1.5	0.9
Fish by-products	2.3	2.5	2.5
Meat and tankage by-products	(7.7)	(7.5)	(7.1)
Processed	5.1	5.3	4.9
Unprocessed	2.6	2.2	2.2
Minerals	2.0	2.1	2.0
Oils	0.1	0.2	0.2
Medicines, drugs, tonics, etc.	2.2	2.1	2.0
Miscellaneous materials	3.1	3.4	4.6
Total	100.0	100.0	100.0

Source: Feed Manufacturers, Catalogue No. 32-214, Statistics Canada.

Other essential ingredients, which are required in only small amounts, include minerals, vitamins, oils and medicines and drugs. The computer has had a particularly valuable application in the manufactured feeds industry since it provides a means of determining the least-cost combination of required nutrients taking into consideration day-to-day changes in prices of alternative ingredients.

Evaluation of Alternative Sources of Protein

Oilseed Meal[1/]

Both oil and oilcake or oilseed meal are derived from the crushing of each type of oilseed in varying proportions. The relative value of the oil and cake components of selected oilseeds and of fish products is shown in Table 20. In the case of soybeans, oil makes up 33 per cent of the value of the seed as compared with 67 per cent for cake, while for rapeseed, oil makes up 68 per cent and cake 32 per cent of the value of the seed.

Oilcakes and oilseed meals are an important source of protein concentrate in livestock feeds. The main components of oilcakes are protein, oil, fibre, nitrogen-free extract, and mineral matter (Table 21). Protein is the general term used for some 23 or more amino acids. Amino acids that cannot be made in the body from other substances or that cannot be made in sufficient amounts are called essential amino acids. Protein for the growth of protein tissues or for the formulation of milk cannot be made by an animal unless it has an adequate supply of

---

1/ World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, Foreign Agricultural Economic Report No. 71, Economic Research Service, U.S.D.A., Washington, D.C. pp. 196-198.

each of the essential amino acids. A shortage of a single one in a feed ration will limit the use of all the others and therefore reduce the efficiency of the entire ration. The essential amino-acid pattern in protein by type of oilcake is presented in Table 22; that of fishmeal is included for comparison.

Table 20. Value of the Oil and Cake Components of Selected Oilseeds and Fish Products, 1967

Commodity	Value of components 1/			Share of total value	
	Cake	Oil	Total	Cake	Oil
	- U.S. dollars per metric ton		-	- per cent -	
Fish products 2/	107	24	131	82	18
Soybeans	78	39	117	67	33
Cottonseed	47	44	91	52	48
Linseed	57	71	128	45	55
Sunflowerseed 3/	35	64	99	35	64
Rapeseed	38	79	117	32	68
Peanuts	53	127	180	29	71
Copra	28	204	232	12	88
Palm products 4/	8	207	215	4	96

1/ Calculated on the basis of prices c.i.f. European ports in 1967.
2/ Values based on average yields of fishmeal and fish oil calculated on a world basis.
3/ Values based on yields of Argentine seed.
4/ Values based on estimated composition of palm fruits from Malayan palm (deli dura).

Source: World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, Foreign Agricultural Economic Report No. 71, Economic Research Service, U.S.D.A., Washington, D.C. p. 126.

In the processing procedure, variations in temperature, pressure and retention time inside the cooker, for example, cause marked differences in the protein content of an oilcake. Thus, an oilcake from one particular oilseed from some suppliers obtains

a premium price over other oilcakes from the same oilseed. Therefore, meals or cakes of different oilseeds processed in different manners possess different amounts of protein, oil and fiber. Digestibility of each of these components differs widely dependong on the type of animal to which the oilcake is fed. Hence, it is difficult to theoretically compare a nutritive value of the different cakes. The feed requirements of the animal must be considered along with the digestibility coefficient of each oilcake.

Table 21. Composition of Various Oilcakes

Oilcakes	Protein	Fat	Fiber	Nitrogen-free extract	Mineral matter	Moisture
	-		per cent			-
Peanut expeller (decorticated)	46.6	6.3	5.5	30.2	5.4	6.0
Peanut extraction	52.3	1.6	6.9	26.3	5.9	7.0
Cottonseed expeller	42.1	6.1	10.5	28.3	5.6	7.4
Cottonseed extraction	41.6	2.0	10.7	31.1	5.6	9.0
Linseed expeller	35.2	4.6	8.9	36.7	5.7	8.9
Linseed extraction	36.6	1.0	9.3	38.3	5.8	9.0
Rapeseed expeller	33.5	8.1	10.8	30.2	6.9	10.5
Copra expeller	21.2	6.7	11.2	47.4	6.5	7.0
Copra extraction	21.4	2.4	13.3	47.4	6.6	8.9
Soybean expeller	44.0	4.9	5.9	30.3	6.2	9.0
Soybean extraction	45.7	1.3	5.9	31.4	6.1	9.6
Sunflower meal (hulled)1/	27.7	41.4	6.3	16.3	3.8	4.9
Sunflower meal extraction (unhulled)	19.6	1.1	35.9	27.0	5.6	10.8
Fish meal	60.9	6.9	0.9	5.0	18.3	8.0
Palm kernel	19.2	6.7	11.9	49.7	3.9	8.6

1/ New Varieties of sunflowerseed have a somewhat higher protein content than this.

Source: Morrison, F.B., Feeds and Feedings, 22nd ed., 1959, pp. 1042-1068, taken from World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, Foreign Agricultural Economics Report No. 71, Economics Research Service, U.S.D.A., Washington, D.C. 1971, p. 199.

Table 22 . Essential Amino Acid Pattern in Protein

Essential amino acid	Peanut meal	Cottonseed meal	Linseed meal	Rapeseed meal	Copra meal	Soybean meal	Sunflower-seed meal
	-		grams per 16 per cent nitrogen				-
Arginine	10.8	11.02	8.55	5.6	10.8	7.0	7.76
Histidine	2.1	2.70	1.86	2.6	1.7	2.5	2.19
Isolencine	4.0	4.01	5.92	3.7	4.0	5.8	4.52
Leucine	6.8	6.20	5.78	5.7	6.2	7.6	5.95
Lysine	4.0	4.20	4.02	3.5	2.6	6.6	3.81
Methionine and cystine	0.85	1.49	1.00	1.1	1.6	1.1	2.19
Phenylainine	5.0	5.25	4.21	4.0	4.2	4.8	5.12
Threonine	2.8	3.47	3.58	3.8	3.3	3.9	3.43
Valine	5.2	4.98	4.92	5.7	5.4	5.2	4.90
Trytophan	1.04	1.59	1.51	2.0	0.9	1.2	1.38
Tyrosine	3.69	-	2.21	2.3	1.8	3.2	-

Source: Altschul, Processed Plant Protein Foodstuffs - 1958, taken from World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, Foreign Agricultural Economic Report, No. 71, Economics Research Service, U.S.D.A., Washington, D.C., 1971, p. 200

Soybean Meal

Soybean meal is one of the best protein supplements for dairy and beef cattle. For swine and poultry, it ranks ahead of all other common protein supplements of plant origin because of the higher quality of its protein. Soybean meal lacks methionine and vitamins, especially as a feed for chickens; another disadvantage is its limited phosphorous and calcium content. During processing, soybean meal is subjected to toasting which destroys the tripsin-inhibitor which is toxic when fed to animals.

Cottonseed Meal

This product is a good protein supplement for dairy cows, beef cows and sheep. Cottonseed meal, however, does not furnish protein of high quality for swine or poultry, chiefly because it is rather low in lysine. Therefore, it should be used in combination with such supplements as tankage, meat scraps, fishmeal, milk byproducts, or soybean meal. Cottonseed meal is one of the richest feeds in phosphorous but it is low in calcium. The toxic compound Gossypol in cottonseed meal (up to 1 per cent of the ration) has no effect on ruminants, but care has to be taken in feeding the oilcake to pigs, poultry and calves.

Linseed Meal

Linseed meal is a high protein and palatable feed for dairy cattle, beef cattle and sheep. It seems to have a conditioning effect on cattle and has a slight laxative effect which aids in keeping stock healthy. Since linseed meal is deficient in lysine and methionine, it should be used in combination with other protein supplements when fed to swine or poultry. Also,

when fed in amounts larger than 5 per cent of the total ration, it has a depressing effect on the growth of chicks and poults. The toxicity due to linase in linseed meal is generally destroyed by the high temperature of operation during screwpressing.

Sunflowerseed Meal

Sunflowerseed meal is a good feed for stock and keeps well. The main disadvantage is the low-lysine content for feeding poultry and swine. Also, the quantity of hulls added to the kernels and the method of processing can limit the use of this meal in swine and poultry feeds because of its high fiber content. Sunflower meal can be used as a supplement to soybean meal since it is rich in methionine, vitamin B12, and calcium and phosphorous.

Copra Meal

Copra meal is a good feed supplement for cattle, particularly dairy cattle, because of its protein content, the characteristic of its residual oil, its palatability, and its high capacity for absorbing molasses. It is not a good feed for swine and poultry because of its high fibre content. The meal's lysine content is high, and lysine is the limiting amino acid in feeding non-ruminants. Copra meal contributes significant amounts of the B complex vitamins to rations.

Peanut Meal

Peanut meal is a good and palatable supplementary protein concentrate for dairy and beef cattle. It is also a good supplement for mature hogs but it produces soft pork. For chicks and young pigs, it is primarily deficient in methionine, cystine, lysine and tryptophan. Many compound feed manufacturers have

generally stopped using peanut meal in feed for poultry and young pigs because of the danger of aflatoxin - which can be fatal.

Rapeseed Meal

The use of rapeseed meal has been limited in livestock feeding because of the presence of active goitrogen. The effect of enzymes labelled goitrogens cause the meal to be toxic to animals - particularly poultry and pigs, in which it causes growing problems and may lead to death. Recently, however, processing methods bave been developed to improve the quality and nutritional value of the meal as an animal feed. Although rapeseed meal is not especially palatable, it has a protein content of around 35 per cent with a good amino acid balance. Its use for animal feeding will probably expand in the future.

Palm Kernel Meal

This meal varies considerably in composition and espesially in fiber content. Palm kernel meal has been used chiefly in Europe where it is mostly fed to dairy cows. Palm kernel meal tends to produce hard fat when fed to stock and thus makes a firm butter and pork of good quality. It is not very palatable to pigs and should not form more than about one-fifth of a ration.

Other High Protein Products

Dehydrated alfalfa meal is produced by subjecting freshly chopped green alfalfa with a moisture content of 60-90 per cent, to a hot de-oxygenized gas steam (1600-1800 degrees Fahrenheit). The dried material is pulverized to a fine meal which may be pelleted for use.

Like many agricultural products, dehydrated alfalfa meal varies considerably in quality. Generally, it averages about 19 per cent crude protein (13½ per cent digestible protein) and contains 75 mg of carotene per pound (equivalent to 125,000 IU of vitamin A). The TDN is 55 per cent and net energy is 46 therms per 100 lbs. It is fairly high in fibre with about 22 per cent crude fibre and contains about 10½ per cent mineral matter.

Dehydrated alfalfa meal is an excellent source of the Unidentified Growth Factors (U.G.F.) both organic and inorganic, and it should be considered along with such products as distillers products, fish products and whey when formulating rations for swine. It is a good source of trace minerals but these are now available at more economical cost from other sources. In poultry rations where yellow pigmentation is desired in egg yolks and in the skin or shanks of broilers, alfalfa meal can be used because of its xanthrophyll content.

The protein quality is fairly good as measured by the amino acid structure but it is considered to be an expensive source of protein, relative to oilseed meals. The production of alfalfa meal has been expanding and there is a good potential for further expansion. One of the principal outlets is the export to Japan. The domestic market should offer an expanding potential outlet but feed manufacturers are less than enthusiastic sbout dehydrated alfalfa meal in terms of its cost in relation to other feeds, such as wheat. The current price of alfalfa meal is about $58.00 per ton at Montreal.

Fishmeal, Feather meal and urea are non-plant proteins which are at present major competitors of oilcake as a high protein supplement animal feedstuffs. The use of fishmeal has expanded greatly since 1955, primarily because of its high portion of protein and relatively low price in relation to oilcakes. However, fishmeal production is not expected to continue in line with past trends. The big growth in production is primarily attributable to Peru. But Peru, according to its Sea Institute, has already attained a level of fishmeal production which should not be exceeded if the fish resources are not to be depleted.

Feather meal or ground hydrolyzed poultry feathers is the product resulting from the treatment under pressure of clean, undecomposed feathers from slaughtered poultry, free of additives and accelerators. In accordance with the Feeds Regulations under the Feeds Act, not less than 70 per cent of its crude protein shall consist of "digestible protein". The monthly average price of 85 per cent feather meal during the first 10 months of 1971 was $124.60 per ton at Toronto, $136.20 at Montreal and $136.35 at Vancouver.

Urea is a synthetic notrogenous compound that is convertible into protein by microbial action in ruminant animals. To be of value, it must be fed with fermentable carbohydrates such as the starches in grain or the sugar in molasses. It may contribute only up to one-third of the protein equivalent in finishing rations or one-fourth in growing rations. One ton of feed-grade urea combined with 6 tons of cereal grain provides the same amount of protein and nearly as much energy as 7 tons

of soybean or cottonseed meal. The use of urea has been especially prominent in the United States, where it is fed primarily to cattle. Its limited use in Europe and Japan to date is due in part to the lack of a significant feedlot fattening industry in these countries. In some European countries, urea use is regulated by law; for example, Germany prohibits the sale of feed urea to farmers. However, in the years ahead, the use of urea in oilcake-importing regions, especially countries which produce substantial quantities of grain, is expected to increase.

By 1980, oilcakes could well be facing substantial competition from products that are presently of minor importance. For instance, the economic feasibility of producing animal feed protein from petroleum cultures has been receiving increasing attention, especially in Europe and Japan.

Another oilcake substitute product that has been receiving increasing attention in recent years is Antarctic krill, which is used for making fishmeal. The shrimp-like krill, which are only 1 or 2 inches long at maturity, are consumed in mass by whales. The reduction in whale numbers in recent years raises the question of whether the krill themselves can be profitably harvested, processed into fishmeal by factory ships, and then transported to the principal markets. It appears that to be economically feasible, fishmeal prices would have to rise above the prices prevailing in the late 1960's.

Research relating to the development of varieties of cereals having a higher percentage protein offers real possibilities in providing alternative sources of feed proteins at

competitive or lower costs than oilseeds. For example, substantial production of high lysine corn for animal feed could reduce the future market for oilcakes. Some types of high lysine corn which have a protein content of 15 per cent, compared with 9 per cent for ordinary corn, might find a particular use in feed for swine and in poultry rations. A major factor determining the economic feasibility of substituting high lysine corn for oilcakes will be the high lysine corn yield attained in relation to regular corn.

Grains and Pulses

The importance of grains and pulses as sources of plant proteins was indicated in Table 1. The composition of cereal grains in terms of nutrients, amino acids and energy, is presented for reference purposes in Tables 23 and 24.

Millfeeds include a variety of materials derived from cereals, particularly wheat, usually by-products of the milling industry. Apart from gluten meal which is commonly rated at 60% protein and gluten feed at 21% protein, the protein content of mill feeds is usually closely associated with the protein content of the parent material, in the case of wheat 10-15 per cent. The principal wheat products are bran, shorts, middlings and feed flour, all of which are from the outer covering or germ of the wheat kernel, with increasing degrees of fineness and decreasing percentage of fibre. Mill feeds have played an important role in traditional livestock feeding practices but make up about 8 per cent of the ingredients in manufactured feeds in Canada.

Table 23. Nutrient Composition of Cereal Grains

	Hard wheat					
	Spring	Winter	Barley	Oats	Corn	Milo
Protein, %	14.0	13.0	11.5	12.0	8.7	11.0
M.E., keal/kg	3250	3250	2840	2620	3430	3250
Ether Extract, %	2.2	2.0	1.9	4.5	3.9	2.8
Crude Fibre, %	2.5	3.0	6.0	11.0	2.0	2.0
Calcium, %	0.04	0.05	0.08	0.10	0.02	0.03
Phosphorus, inorg. %	0.13	0.13	0.17	0.15	0.10	0.10
Vitamins						
Riboflavin, mg/kg	1.1	2.0	2.0	1.1	1.3	1.2
Nicotinic Acid, mg/kg	60.0	60.0	57.0	18.0	22.0	40.4
Pantothenic Acid, mg/kg	13.0	13.0	6.6	13.0	5.7	11.0
Choline, g/kg	1.0	1.0	1.1	1.1	0.62	0.68
Pyridoxine, mg/kg	4.0	4.0	2.9	1.3	7.0	4.0
Biotin, meg/kg	0.11	0.11	0.15	0.11	0.06	0.18
Folic Acid, mg/kg	0.40	0.35	0.50	0.30	0.36	0.24

Source: Scott, M.L. and others; Nutrition of the Chicken, M. L. Scott and Associates, Publishers, Ithaca, N.Y. 1969.

Table 24. Amino Acid Composition and Energy Content of Cereal Grains

	Hard wheat					
	Spring	Winter	Barley	Oats	Corn	Milo
Protein	14.0	13.0	11.5	12.0	8.7	11.0
M.E., keal/kg	3250	3250	2840	2620	3430	3250
Amino Acids						
Arginino, %	0.70	0.60	0.53	0.80	0.50	0.36
Cystine, %	0.25	0.22	0.18	0.22	0.18	0.15
Glycino, %	0.70	0.60	0.36	0.50	0.50	0.40
Histidine, %	0.30	0.26	0.27	0.20	0.20	0.19
Isoleucine, %	0.70	0.60	0.53	0.53	0.40	0.46
Leucine, %	0.90	0.80	0.80	0.90	1.10	1.40
Lysine, %	0.45	0.40	0.53	0.50	0.20	0.20
Methionine, %	0.20	0.17	0.18	0.18	0.18	0.13
Phenylalanine, %	0.70	0.60	0.62	0.60	0.50	0.47
Threonine, %	0.42	0.36	0.36	0.40	0.40	0.36
Tryptophan, %	0.18	0.10	0.18	0.16	0.10	0.12
Tyrosine, %	0.60	0.50	0.36	0.53	-	0.70
Valine, %	0.60	0.50	0.62	0.70	0.40	0.53

Source: Scott, M.L. and others; Nutrition of the Chicken, M.L. Scott and Associates, Publishers, Ithaca, N.Y., 1969.

Brewers' and distillers' grains are another important type of mixed-feed ingredients which are derived from cereals and are by-products of the brewing and distilling industry.

Comparative Costs of Protein from Different Sources

The comparative costs of protein from Canadian grains, legumes and oilseed meals are presented in Table 25.

One of the main objectives in this table is to present a meaningful analysis of the relative costs of protein derived from different products. In this connection, it is essential to keep in mind that these products are multi-purpose and to provide a proper valuation of each type of end use. In order to obtain a comparative cost per pound of protein from each source, the carbohydrates have been valued conservatively at $1.50 per cwt. of carbohydrates. No value has been allocated to cereal oils which at least in the case of corn is very substantial. On this basis, the cost per pound of protein is calculated to be 7.6 cents and 9.6 cents, respectively, from rapeseed meal and soybean meal as compared with 10.2 cents from barley, 10 cents from oats and 12 cents from wheat. Corn at 16.5 cents per pound of protein was the highest cost source.

Table 25. Comparative Evaluation of Canadian Grains, Oilseed Meals and Legumes as Sources of Protein

	Production average 1966/70			Calculations based on 100 pounds of product					
					Carbohydrates		Protein		
	Quantity	Protein equivalent	Feed use	Price 1/ Montreal	Quantity	Value: $1.50 cwt.	Quantity	Residual value	Cost of protein per lb.
	million metric tons		per cent	$ per cwt.	lb.		lb.	$	cents
Wheat	16.8	2.2	20	2.50	70	1.05	12	1.45	12.0
Corn	2.0	0.24	60	2.55	70	1.05	9	1.50	16.5
Oats	5.5	0.7	90	2.00	60	0.90	11	1.10	10.0
Barley	7.2	0.9	90	2.20	65	0.98	12	1.22	10.2
Peas, dry	0.033	0.007	-	3.50	70	1.05	22	2.45	11.1
Soybeans	0.2	0.06	60						
Soybean meal	0.46	0.22	90	5.15	30	0.45	49	4.79	9.6
Rapeseed	0.8								
Rapeseed meal	0.07	0.026	100	3.05	30	0.45	34	2.60	7.6
Flaxseed	0.6								
Linseed meal	0.04	0.014	100	4.00	50	0.75	36	3.25	9.0
Alfalfa meal			100	2.90	55	1.10	19	1.80	9.5

Source: Production Yearbook 1970, FAO, Rome.
Oil World 1971
Oilseeds Review, September 1971, DBS.

1/ Estimated c.i.f. feed mill prices, Montreal.

CANADA'S PROSPECTS AS A SUPPLIER OF PROTEIN FEEDS

Future Market for Canadian Protein Feeds

In considering Canada's future prospects as a supply of protein feeds, it may be useful first to look at the future demand for feeding stuffs as indicated in a study on future market outlets for Canadian wheat and other grains prepared in 1969 by the writer for the Economic Council of Canada.[1/]

Wheat.- Over a recent 20-year period, an average of 27 per cent of the annual disposition of Canada's wheat has been for domestic use and 73 per cent has been for export.

During the 20-year period, an average of 154 million bushels of wheat was used domestically. Of this amount, 58 per cent have been used on farms for seed and feeding livestock and 42 per cent have been marketed through commercial channels for processing into flour or other food products, for industrial use and for use in the feed compounding industry.

The use of wheat on farms for livestock feeding varies from year to year and is influenced by the build-up of farm stocks resulting from insufficient delivery quotas to clear current production off farms. During this 20-year period, the use of wheat in livestock feeding varied from a high of 77.6 million bushels in 1955 to a low of 44.1 in 1961. The current build-up of wheat stocks on farms could easily result in an increase in the use of wheat for livestock feeding to about 90 million bushels by 1975.

1/ Hudson, S.C., Future Market Outlets for Canadian Wheat and Other Grains, Queen's Printer, Ottawa, 1970.

Taking both domestic and export demand into account, total utilization of wheat in Canada in 1975 may amount to about 562 million bushels.

Coarse Grains.- The disappearance of coarse grains in Canada reached a peak of 849 million bushels in 1966 as compared with an average of 717 million bushels for the five years 1956 to 1960. About 90 per cent of the total volume of coarse grains is used domestically. Some 50 per cent of the coarse grains in Canada is oats, 95 per cent of which is used domestically. Barley makes up about 30 per cent of the total volume of coarse grains. About 70 per cent of the barley is used domestically and 30 per cent goes into export channels.

Rye makes up only a very small proportion of the total volume of coarse grains, but over 50 per cent is exported. The proportion of corn in the total volume of coarse grains has been increasing rapidly, and currently amounts to about 13 per cent of the total. About one-third of the corn used is imported.

Slightly more than 2 per cent of the coarse grains used domestically is used for food. The coarse grains used as food are primarily oats and corn. Seed and industrial use each accounted for about 5 per cent, with livestock feed making up about 88 per cent of the total domestic utilization of coarse grains. The coarse grain requirements in 1975 will therefore depend on the changes in consumption of animal products, that are anticipated.

Projections of the consumption of meat, poultry and dairy products in Canada indicate that, as compared with the base period

1964/65, projected consumption in 1975 will show increases of 9.3 per cent for dairy products, 32 per cent for red meats and 48 per cent for poultry meat[1/]. Consumption of beef is projected to increase by 40 per cent over the 1964/1966 average.

Projections of the number of animals required for slaughter in 1975 show a substantial increase over 1964/1966, amounting to 34 per cent for cattle, 27 per cent for hogs and 48 per cent for poultry.[2/]

The projected increases in the number of animals slaughtered and the numbers on farms suggest increases in total feed grain requirements by 1975 of 20 or 27 per cent depending on the efficiency of feeding.[3/] In terms of all grains, the 1975 feed requirement would be between 840 and 890 million bushels, an increase of 140 to 190 million bushels over the average for 1964/1966. Allowing for seed and industrial use, the total domestic disappearance of coarse grains in 1975 should be between 900 and 950 million bushels.

World imports of coarse grains averaged 41.6 million metric tons during the three years 1965/1967 as compared with 20.5 million tons during the three years 1957/1959, an increase of 105 per cent. The FAO projections indicated a leveling-off in the rate of growth of consumption of coarse grains and a relative gain in production in importing areas.

1/ Yankowsky, Z.J., Frank Shefrin, J. F. Cavin, Demand -Supply Projections for Canadian Agriculture in 1980, Economics Branch, CDA, Ottawa, June 1968.
2/ Ibid, p. 40
3/ Ibid, p. 42

On the basis of the FAO and OECD projections of the consumption and production of coarse grains in 1975, world imports of coarse grains for 1975 are forecast at between 30 and 35 million tons. The lower point of this range would represent a decrease of 28 per cent in imports of coarse grains from the level of the past three years.

Corn makes up 62 per cent of the world's exports of coarse grains as compared with 16 per cent each for barley and for millet and sorghums. The exports of corn and millet and sorghums have increased threefold during the past decade while those of barley have remained relatively unchanged.

The United States, whose exports of corn have tripled in the last decade, provides 56 per cent of the coarse grains exported. Other important exporters of corn are Argentina and South Africa which in the last three years supplied 12 and 3 per cent, respectively, of world exports of coarse grains. During the 1967/69 period, the United Kingdom and the EEC have been important exporters of barley with the aid of export subsidies, making up 2 and 4 per cent of coarse grains exports.

Canada was not a strong competitor in the coarse grain export market up to 1970. Total exports of coarse grains from Canada declined from an average of 85 million bushels for the 1956 to 1960 period to a low of 28 million bushels in 1968. Exports of oats, which have varied greatly from year to year, increased from an average of 12 million bushels during 1956/1960 to 19 million bushels in 1963 but have declined during the last three years to a low of two million bushels in 1968. Exports of rye, which also have varied from year to year, amount to four million bushels.

Barley, the only coarse grain which Canada exports in quantity, had average exports of 69 million bushels during the 1956 to 1960 period. Since then, exports varied but dropped sharply to 21 million bushels in 1968. This sudden decrease in exports was due to the loss of the EEC market and to a drop in exports to Japan from 15 million to 800 thousand bushels as a result of competition from heavily subsidized exports from France.

Yields of barley reported by the agricultural research stations and by the more successful farmers in Western Canada are extremely encouraging with respect to the potential of barley competing with U.S. corn in a market where the competition would be based on feeding value.

In the past decade, barley's share in the world export of feed grains has declined from 30 to 16 per cent. This means that in order to obtain a substantial share of the world market for feed grains, it will be necessary for Canada not only to price barley competitively with corn but also to carry on an educational campaign in importing countries to publicize the feeding value of barley in comparison with corn and the economies involved in the use of a larger proportion of barley in feeding rations. It is largely on the basis of this potential and the fact that Canada is an established supplier of barley to Japan, which is likely to continue to expand her feed grain imports, that exports of Canadian barley in 1975 are projected at about 125 million bushels.

This export potential, together with the increased feed grain requirements to provide for Canada's expanded livestock population, suggests outlets by 1975 for 1,075 million bushels of Canadian coarse grains.

To up-date the above 1975 projections, reference is made to the review of the feed grain situation presented at the 1971 Agricultural Outlook Conference which indicated that world exports of feed grains increased to a new record of 44 million tons in 1970 which was 3 million higher than the previous record established in 1967/68 and 30 per cent higher than the 1975 projected trade volume. The growth in trade is accounted for by the continued expansion of livestock production and the reduced production particularly in Europe and Japan. The largest expansion occurred in the EEC whose feed grain imports were 46 per cent higher than in 1969/70. The total volume of world trade in corn was not greatly affected by the curtailed U.S. corn supplies because the deficit was met by larger imports from other countries including Argentina, Canada, Thailand and Brazil. A substantial part of the increased demand was met by feed grains other than corn. For example, barley exports rose sharply by 30 per cent above average levels, and trade in oats showed a recovery from the exceptionally low levels of 1969/70.

Canadian production of feed grains (barley, oats, corn and mixed grains) in 1971 amounted to 26.7 million tons; this is more than a 25 per cent increase over 1970. Almost all of this increase is attributable to barley which was higher by 5.5 million tons.

Domestic barley utilization in 1971/72 should remain at about the 1970/71 level of 293 million bushels as compared with the 1964/65 to 1968/69 average of 196 million bushels.

Exports of barley in 1971/72, despite the difficult competitive situation, are expected to about equal or exceed the 1970/71 export level of 180 million bushels, which was far in excess of exports of any other previous year. While many aspects of the world situation in 1972/73 are uncertain at present the ability to export sizeable quantities this crop year indicates that as long as barley is price competitive a high sales level is likely to be successfully made in 1972/73 as well.

Production of oats in Canada in 1970/71 has been estimated at 371 million bushels, almost the same as last year. Domestic use of oats in Canada in 1970/71 in total appears to have increased slightly. Exports of oats in 1970/71 increased threefold to 12 million bushels. No significant increase over last year's total is expected and the domestic market will still remain the only substantial area of disposition. Oats will continue to have a role particularly in on farm feeding throughout all areas of Canada. However, during the last year its importance in the growing feed grain industry declined relative to barley, and this trend is likely to continue.

Canadian corn production at 101 million bushels almost exactly equalled production in 1970. Imports in 1970/71 at 12.7 million bushels were only about 45 per cent of previous years' imports. The trend away from U.S. imports should continue after 1971/72 since Canadian

production has been more widespread and indications are that production will continue to increase.

The above projections of the number of animals required for slaughter in 1975 showed an increase in relation to the 1964/65 base period of 27 per cent for hogs and 48 per cent for poultry. Although available feed grains generally contain almost sufficient protein for most rations for cattle and sheep, the above increases in the number of hogs and poultry will require substantial increases in high-protein feeds to provide for their high protein rations. This could mean an increase of up to 150,000 tons of protein equivalent by 1975 and perhaps double that amount by 1980.

Research Needed on Alternative Sources of High-Protein Feeds

As indicated in Table 15, 86 per cent of the protein provided by the high-protein feeds consumed in Canada, are derived from soybean meal, of which about 70 per cent are imported, either as beans or as meal. The provision of a greater part of Canada's high-protein feeds from domestic production presents a challenge to Canadian agricultural scientists and industry to develop alternative sources of protein for feeding purposes.

<u>Oilseeds</u>

<u>Soybean</u> production in Canada was stimulated by the availability of an export outlet in the United Kingdom under Commonwealth preference rates of duty, which provided an advantage over exports from the United States. The loss of this preference in connection with the Kennedy Round tariff negotiations, has been a major factor in the reduction of Canadian exports of soybeans from an average of 2.3 million bushels for the period 1964/65 to 1968/69 to 1.1 million bushels in 1969/70 and 768 thousand bushels in 1970/71. In spite of this reduction in exports, acreage of soybeans has continued to increase from 272,000 acres for the 1964/65 to 1968/69 period to 360,000 acres in 1971/72. At the same time the volume of imports of soybeans from the United States has been maintained. Since the production of soybeans in Canada is confined to Southwestern Ontario, the extent of expansion of Canadian soybean production would seem limited in view of the attractive alternative crops available to farmers in Southwestern Ontario.

<u>Flaxseed</u> production in Canada in 1971 is estimated at 26.8 million bushels compared with 48.9 million in 1970. Crushings in Canada which averaged 2.5 million bushels in the 1964/65-1968/69 period, was 2.8 million bushels in 1970/71. Flaxseed yields 35 per cent oil, which is used for non-edible industrial uses, and 64 per cent linseed meal which has a raw protein content of 36 per cent. The limited prospects for exports of flaxseed and a limited domestic market for linseed oil is likely to discourage any great expansion in production of flaxseed and linseed meal.

Sunflower seed production increased rapidly in the past two years from an average of 1 million bushels for the period 1964/65 to 1968/69 to over 5 million bushels in 1971/72. Sunflowerseed yields 44 per cent crude oil and 17 per cent oilmeal, both of which are high quality. Sunflower meal has a raw protein content of 43 per cent. The potential for increased sunflower production would seem to be very good.

Rapeseed production in Canada has expanded from an average of 8 million bushels for the 1959/60 to 1963/64 period to a record 98 million bushels in 1971/72 (Table 26). Exports which have increased from a 1959/60 to 1963/64 average of less than 6 million bushels to about 47 million bushels in 1970/71, account for about 65 per cent of the crop (Table 27). Rapeseed yields 39 per cent oil and 57 per cent meal, which has a protein content of 34 per cent. Researchers have made a notable contribution in the development of rapeseed as an export crop and as an acceptable alternative source of vegetable oils and oilmeal for domestic use, although some technical problems still require solution. It would seem to the writer that in the development of an oilseed crop, attention is focused primarily on the technical aspects of the production and marketing of the vegetable oil and that the economic aspects of the marketing of the meal as a source of high protein meal, for which the market demand is growing rapidly, has received inadequate consideration. It is suggested that continuing consideration be given to the technical problems relating to rapeseed meal but also that equal

priority be given to logistic and other economic problems concerned with the crushing and the marketing of rapeseed meal in Canada.

Table 26. Rapeseed: Acreage, Yield, Supply, Disposition and Prices, Canada, 1959 to 1971 (Crop Year August 1 to July 31)

	Average 1959/60 to 1963/64	Average 1964/65 to 1968/69	1969/70	1970/71	1971/72 (Estimated)
Acreage (thousand acres)	507	1,285	2,012	4,050	5,475
Yield (bushels per acre)	15.8	16.5	16.5	17.8	18.0
	-		thousand bushels		-
Stocks at August 1	704	4,219	5,069	3,633	9,854
Production	8,024	21,146	33,400	72,200	98,500
Total supply	8,728	25,365	38,469	75,833	108,354
Exports	5,781	12,669	22,213	46,811	
Domestic disappearance	2,116	7,639	12,623	19,168	
Stocks at July 31	831	5,057	3,633	9,854	
	-		dollars per bushel		-
Average farm price (all grades)	1.95	2.25	2.29		

Mustard seed which is closely related to rapeseed, is considered by some scientists to have interesting potentialities as a source of oil and protein. Enquiries directed by the writer to Mr. S. H. Pawlowski, CDA Research Station, Saskatoon, elicited a letter and a CANADEX copy which provide some of the results obtained from research on mustard seed (Appendix I). It would seem to the writer that the results of research available to date would justify a crash program of research on both rape and mustard seed in which particular consideration is given to the need for an economic alternative to soybeans as a source of oilmeal.

Table 27. Major Importers of Canadian Rapeseed, 1957-1958 to 1969-1970

Crop Year	Japan	United Kingdom	Belgium-Luxembourg	West Germany	Italy	Netherlands	All Others
	-			thousand bushels			-
1957-1958	739	62	20	1,110	2,238	2,092	88
1958-1959	976	22	11	459	2,221	1,926	55
1959-1960	2,289	31	7	-	138	10	472
1960-1961	877	169	311	607	2,949	845	2,317
1961-1962	1,231	146	108	226	3,320	988	898
1962-1963	3,080	73	158	215	1,358	372	414
1963-1964	4,331	92	-	6	189	167	636
1964-1965	2,567	357	68	638	1,462	1,036	2,107
1965-1966	6,986	162	335	1,075	2,804	1,470	794
1966-1967	8,404	158	-	68	3,163	960	1,056
1967-1968	10,197	-	-	-	324	307	1,457
1968-1969	10,909	-	-	64	184	143	2,917
1969-1970	14,390	698	304	967	842	2,796	2,210

Source: Statistics Division, Board of Grain Commissioners of Canada.

<u>Pulses</u>.- Pulses which generally have a protein content of between 20 and 30 per cent are one of the most important sources of protein for both food and livestock feed in many countries of Asia. Dr. J. W. Morrison, A/Assistant Director-General, Planning and Co-ordination, Research Branch, CDA, Ottawa, provided a report on research in field peas, lentils and horse beans (Appendix II). A report on investigation being carried on at the Prairie Regional Laboratory of the National Research Council on "peas for food and feed" indicates "a real potential for expanding the production and use of field peas in Western Canada" (Appendix III). Research on the feeding of peas is being carried on by Dr. J. M. Bell, University of Saskatchewan, Saskatoon. It is understood that these crops are very good from the standpoint of protein quality and content but that at present the yields per acre are not economic. There would seem to be considerable advantage in concentrating large research inputs on a crop like peas which can be grown anywhere in Canada, in search for an economic alternative source of protein.

<u>Grains</u>.- In view of the large aggregate contribution of grains to the available supplies of plant protein, it is suggested that priority should be given to research on cereals in an effort to develop alternative sources of protein. Because of the high quality of protein in oats, the writer was particularly interested in research being carried out on high protein oats by Dr. Vernon Burrows, Chief, Cereal Section, Ottawa Research Station, CDA. Dr. Burrows' letter and attachments which are extremely informative are

in Appendix IV herewith. It would seem that the research being carried out on oats offers real possibilities of developing more economic sources of protein for both livestock feeding and food use.

Need for Improved Grading Standards for Feed Ingredients

There is a wide variation in the quality within each type of coarse grain and other feed ingredients. Technical progress in the development of economic and nutritionally correct rations for different types of livestock at different stages of growth by combining a variety of ingredients with known characteristics has made existing grades for coarse grains obsolete. The need for an improved grading system for grains used for feedingstuffs which would take account of protein content and other factors affecting feeding value was emphasized by the late Edwin F. Marritt in "An Assessment of the Canadian Feed Grains Market" prepared for the Canada Grains Council in June 1970. Feed Grain Grading Standards received considerable attention at the Twentieth Annual Meeting of the Canada Committee on Animal Nutrition held in Winnipeg, March 2 and 3, 1971. Opinions expressed supported a need for practical methods of estimating available energy in grain and using both energy and protein as grading criteria in the interest of both feed manufacturers and farmers. The Canadian Feed Manufacturers' Association has established a technical sub-committee which has the grading of coarse grains under review and has made recommendations for changes in the traditional grading system for grains which would take into account their nutritive value in feedingstuffs.

It seems to the writer that there is considerable evidence that protein and other quality criteria are not properly valued in the pricing of grain in the market place. Without assurance that he will be paid for quality of product, there is no incentive for farmers to produce improved types of crops which have been developed by the research scientist. Similarly, the buyer is justified in demanding a certificate of nutritional quality.

The report of the Ad Hoc Committee on Feed Grain Specifications (Grade and Quality) of the Canada Grains Council refers to the report of the Feed Grains Utilization Sub-Committee in which "energy content is singled out as being the most important criteria for a grain which is to be utilized as a livestock feed. High protein levels in feed grain are considered to be of secondary importance, as alternative sources of protein are readily available to bring rations up to the level required".[1/]

The writer suggests that this statement may reflect the interest of a feed manufacturer who is interested in maximizing sales of protein supplements, rather than that of a farmer-feeder who can minimize his cash cost of protein supplements by growing an improved grain which will yield more protein per acre. The statement also infers that the cost of protein from soybeans is much cheaper than that from grains which is not the case. Very often it appears that the cost of protein from grains is calculated without giving any credit for the carbohydrate content, thus obtaining an inflated cost of protein.

1/ Report of the Ad Hoc Committee on Feed Grain Specifications (Grade and Quality) to to the Canada Grains Council, October 19, 1971.

The same report also states, "The best measure of energy available to the grader today appears to be test weight per bushel. Therefore, a higher test weight per bushel generally reflects a higher feeding value. This view is reflected in the suggested test weights of the proposed new grades". Data presented by Sibbald and Slinger (1963) on the composition of samples of western Canadian grains shows that the variation in energy content is not correlated with bushel weight in protein content with the exception of oats.1/

In a paper on "The Prediction of the Metabolizable Energy Content of Poultry Feedingstuffs from a Knowledge of Their Chemical Composition"2/ Sibbald and Others, using data pertaining to chemical compositions of 87 samples of diets and feed ingredients, found that the equation of Carpenter and Clegg (1956) shown below, is capable of predicting classical metabolizable energy values for most feedingstuffs with sufficient precision for most practical purposes, where starch, sugar, crude protein, ether extract and dry matter, are expressed as gm. per gm. feedingstuff:

ME (Cal./gm. dry matter =

$$0.059 + 3.8 \left(\frac{1.1X \text{ starch} + \text{sugar} + \text{crude protein} + 2.25X \text{ ether extract}}{\text{dry matter}}\right.$$

It is suggested that this approach be explored as a means of measuring energy in a grading system for coarse grains which would provide standards relating to both energy and protein.

1/ I. R. Sibbald and S. J. Slinger, nutritive values of ten samples of western Canadian grains, Poultry Science, Vol. 42, pp. 276-277.

2/ I. R. Sibbald, J. Czarnoble, S. J. Slinger and G.C. Ashton, The Prediction of the Metabolizable Energy Content of Poultry Feedingstuffs from a Knowledge of Their Chemical Composition, Poultry Science, March 1962, Vol. 42, No. 2, pp. 486-493.

Conclusions

1. A projected increase by 1980 of some 30 per cent in the world demand for animal proteins, particularly meats, will be reflected in a very substantial increase in the world market for feed proteins, especially in the EEC, Japan, the United Kingdom and other European countries, which will continue to account for over 90 per cent of world imports.
2. A continuation of the current rate of increase in the demand for meats in Canada will result in a very great expansion in the domestic market for protein feeds.
3. A rough estimate indicates that the percentage of the plant proteins consumed by livestock which is supplied from fodder crops and pasture amounts to about 80 per cent on a world basis, and to about 65 per cent for Canada. The low protein content of much natural vegetation suggests a need for an economical source of protein supplement for cattle and sheep on range-type grazing land.
4. Soybean meal from the United States is supplying an increasing share of the world market for high protein feeds and by 1980 is likely to account for over 70 per cent of oilmeals exported.
5. Some 85 per cent of the protein equivalent of concentrates fed to livestock in Canada is supplied from

cereals. Of the high protein feeds making up the balance of the plant protein ingredients in the aggregate Canadian feed rations, 85 per cent is soybean meal, of which 75 per cent is imported.

6. When a reasonable allowance is made for the value of the carbohydrate element, the cost of protein in oats, barley, peas and wheat is roughly comparable to that in soybeans.

7. In order to provide an opportunity for Canadian farmers to supply a larger share of the rapidly expanding feed protein market in Canada, there is an urgent need for a research program covering the functional aspects of the chemistry of protein derived from oats, barley, peas and wheat, and for a greatly expanded research effort on the production of improved varieties of these cereal crops, taking into account the need for alternative domestic sources of both plant protein and energy.

8. Research and development work on rapeseed and mustard seed as sources of vegetable oils and oilseed meals should continue to be given high priority. Particular consideration should be given to the increased use of oilseeds from these crops in livestock feeds and to the possibility of developing export outlets for refined rapeseed and mustard seed oils.

9. There is an urgent need for a thorough study of all factors involved in the development of adequate grading standards for grains, pulses, oilseed meals and other ingredients in processed feeds, which will take into account their protein and energy content. Towards this end the development of rapid methods of measuring protein and energy is required.

CANADA DEPARTMENT OF AGRICULTURE / MINISTÈRE DE L'AGRICULTURE DU CANADA

RESEARCH BRANCH – DIRECTION DE LA RECHERCHE
Research Station
University Campus
SASKATOON, Saskatchewan

Mr. S. C. Hudson
Office of the Minister
The Honourable Otto E. Lang
Grains Group
Room 5009
West Memorial Building
OTTAWA, Ontario
K1A OH5

YOUR FILE NO
VOTRE RÉF Nº

OUR FILE NO
NOTRE RÉF Nº

25 November 1971

Dear Mr. Hudson:

I have your request for information on mustard as a source of oil and protein.

I am enclosing a CANADEX copy which outlines some of the comparisons between rapeseed and mustard. We are not making any further comparisons of agronomic features but are pursuing various objectives in mustard.

One of the possibilities in both Yellow (B. hirta) and Oriental and Brown mustard (B. juncea) is their use as possible sources of high erucic acid oil. In B. hirta we have so far found material that has a range of 1-57% erucic and in B. juncea we have 9-62% erucic. It should be possible to obtain higher levels in both species. It is too early to predict what erucic acid content requirements of mustard for condiment may be in the future. If the high erucic types are considered suitable for condiment, then its high erucic oil could give mustard an alternative use, especially for low grade mustard seed.

B. hirta is often used as whole seed or flour in many prepared meats such as various sausages. The mucilage content of the mustard imparts desirable physical characteristics to the product. It absorbs moisture and produces a firmer product which peels easier from its casing. Mustard can be heated to destroy the enzyme, myrosinase, which is required to give it the characteristic mustard flavor. Such heated mustard has a bland flavor and can be used in larger quantities to achieve the desired effects without the characteristic mustard flavor. Here is where more mustard meal could be used if it was an economic source of high erucic acid oil. B. juncea cannot be used for this purpose because it contains little mucilage and has a bitter taste even after the enzyme is destroyed.

Low grade B. juncea and B. hirta mustard has been crushed at Culbertson, Montana, in 1970. The oil was sold at Rotterdam and the meal sold locally for livestock feed. Growers were paid 1 to 2 cents a pound for the seed used for crushing. Mustard seed meal produced under present processing methods is not as palatable as rapeseed meal and would have to be fed in more limited quantities. Feeding studies have indicated that palatability is a problem in feeding mustard meal to most livestock.

In interspecific crosses with rapeseed, glucosinolate-free rapeseed plants have now been obtained but no glucosinolate-free mustard plants have so far been obtained.

The oil content of Oriental mustard is in the 37-44% range which is equal to that of B. campestris rapeseed. Yellow mustard (B. hirta) is 27-34% oil.

The fatty acid composition of the commercial mustard presently grown in Western Canada is:

Fatty acid	B. juncea	B. hirta
Palmitic	4%	3%
Oleic	22	20
Linoleic	20	8
Linolenic	14	12
Eicosenoic	15	12
Erucic	25	45

There is some work on protein quality being done at the Prairie Regional Laboratory of N.R.C. at Saskatoon, but is of quite a basic nature. Dr. J. M. Bell of the Animal Science Department, University of Saskatchewan, Saskatoon, has done some nutritional studies using mustard meal of the B. juncea species. You may contact him for his opinions on it.

The accelerated research program in rapeseed is closing some of the gaps that existed in these two crops. However, with the emphasis on low erucic acid varieties in rapeseed, the use of a different crop for high erucic oil that would not cross-pollinate with rapeseed would have definite advantages in growing and marketing it. I feel that objectives in mustard that complement rapeseed rather than compete with it are ones to be considered first. At the present time the condiment trade is the only existing market for this crop. It has been a surplus commodity for the past four years and has not been as economically attractive as rapeseed during that same period. A quarter of a million acres has supplied our annual requirements for our present markets. I feel that work leading to alternative uses for mustard would be a field that would give the greatest potential return.

.... 3

This would include the development of processing techniques which could produce products suitable for human food. Since mustard is already accepted as a component of the human diet, it should be more readily accepted in new products than the use of a new commodity that may have been associated with livestock feed.

Yours very truly,

Sid Pawlowski

S. H. Pawlowski
Research Scientist
Oilseed Crops

SHP/gh
Enc.

FIELD CROPS

APPENDIX I (contd)

POTENTIAL OF CROSSES BETWEEN RAPE AND MUSTARD

Rapeseed is grown over an extensive area of Western Canada that varies considerably in climatic and soil conditions. Present varieties of rapeseed belong to two species, *Brassica napus* and *B. campestris*, which differ in maturity by as much as 3 weeks. The relative performance of these two species varies with the season and area of production. Variety tests have indicated that there are large areas that could grow varieties with an intermediate maturity rather than be limited to the present varieties. Also, since much of the recent expansion in production moved into the drier areas, it has raised the possibility of considering other species which are better suited to these conditions.

Until about 1960, mustards belonging to the *B. hirta* and *B. juncea* species were grown only in the drier areas as an alternative to wheat. However, production had to be limited to about 250,000 acres because of the limited market for mustard seed. The price paid to the producer for mustard seed of the *B. juncea* species has always been well below that of rapeseed, often only about half of that of rapeseed. Mustard (*B. juncea*) has shown a number of favorable agronomic features over rapeseed. It is more widely adapted, especially to the drier areas, competes with weeds more readily and is considerably more resistant to shattering than rapeseed. It also has an advantage in seed yield as illustrated in Table 1.

TABLE 1. YIELD IN POUNDS PER ACRE AND DAYS TO MATURE OF COMMERCIAL MUSTARD AND RAPESEED VARIETIES

	Yield lb/ac			Days seeding to maturity		
Crop and variety	1962	1963	1964	1962	1963	1964
No. of stations	8	17	5	7	13	4
B. napus						
Nugget rapeseed	1286	1471	1027	104	101	99
Tanka rapeseed	1309	1579	1034	104	103	99
B. campestris						
Arlo rapeseed	1081	1150	1225	85	84	81
Echo rapeseed	1230	1338	1194	86	86	81
B. juncea						
Brown mustard	1373	1626	1364	96	92	94
Oriental mustard	1474	1674	1346	94	92	94
B. hirta						
Yellow mustard	1157	1337	1048	89	88	90

Note that during the 3 years of the test superior yields were obtained from *B. juncea*, and its maturity requirement was intermediate between those of the two rapeseed species. These tests covered an extensive area of Western Canada.

TABLE 2. PROTEIN CONTENT OF COMMERCIAL MUSTARD AND RAPESEED VARIETIES 1965

	% protein in oil-free meal				
	Rapeseed		Mustard		
Location	Echo	Tanka	Brown	Oriental	Yellow
Winnipeg	41.7	44.7	44.8	46.6	46.2
Indian Head	42.1	45.1	48.0	49.9	49.5
Fargo, N.D.	42.0	45.1	46.3	48.1	47.8
Minot, N.D.	41.4	44.4	46.8	48.7	48.3
Outlook	41.1	44.0	45.5	47.3	47.0
Scott	43.5	46.7	46.9	48.7	48.4
Average	42.0	45.0	46.4	48.2	47.8

Another very significant feature is the difference in protein content of the oil-free meals of mustard and rapeseed. The difference between Oriental mustard and Echo rapeseed meal in protein content is of special interest since the *B. campestris* species makes up 80% of our total production. One of our present problems is the inverse relationship between oil and protein content in our rapeseed crop. Here is a situation where Oriental mustard is practically identical to Echo rapeseed in oil content but is considerably higher in protein content. This would be a very desirable feature to incorporate into an oilseed crop.

Countries that use oilseed meals for fertilizer might consider using Oriental mustard for this purpose. It would provide a higher protein meal at a lower price. The fatty acid composition of the oil is very similar to that of Echo rapeseed. One difference is that mustard oil has a linolenic acid content of about 14% compared with 10% in Echo rapeseed oil. Oriental and Brown mustard are used as sources of edible oil in Pakistan.

Another interesting feature in Table II is the difference between Brown and Oriental mustard in both oil and protein content. Oriental mustard is higher in both oil and protein content. The difference in oil content is in the order of 2 to 3%. Close examination of the seed coats of the two mustards indicated that the yellow seed coat of Oriental mustard is considerably thinner than the seed coat of Brown mustard. In a more detailed study comparing yellow and brown seeds in Echo rapeseed, it was indicated that yellow seed coats were associated with several desirable features. Yellow seeds proved to be 1.9% higher in oil content, the meal was 3.2% higher in protein and fiber content was reduced from 12 to 7.5%. Seed size was found to have a relatively minor

effect on these factors. Yellow seed in the *B. napus* species would no doubt have a similar effect and interspecific crosses may be a means of establishing this feature in that species.

Interspecific crosses at Saskatoon have been confined to *B. juncea, B. napus* and *B. campestris* species. Since they all have the A genome in common, they cross relatively easily. Oriental mustard (*B. juncea*) contains sinigrin, which gives the meal its better taste but does not contain any of the glucosinolates present in rapeseed. The variety Bronowski which is practically free of glucosinolates was used for the *B. napus* species. One of the objectives was to obtain glucosinolate-free plants from these crosses.

When a high oil content strain of *B. juncea* was used with Echo rapeseed in the initial cross, F_1 plants were highly sterile. Doubling the chromosome number of F_1 material resulted in increased fertility but the improvement in fertility of subsequent generations was slow. A disadvantage of chromosome doubling was evident following analysis for glucosinolate content. Plants were found to contain the glucosinolates of their parents rather than segregate into some glucosinolate-free plants. Further work with this high chromosome number material has therefore been drastically reduced.

A striking feature of the variety Bronowski is the case with which one can obtain F_1 seed when crossed with *B. campestris.* Although the fertility of all F_1 plants was low, crosses with Bronowski were more fertile. Occasional plants in all crosses were found to regain their fertility very rapidly in the F_2 and F_3 generations.

Many unusual characteristics have been observed in the F_2. Most of these may not have any practical application but some plants show very desirable combinations of certain features. Unfortunately the plants are not found to be free of glucosinolates. With present parental material the chances of obtaining superior types directly through interspecific crosses appear quite remote. However, improvement in parental material such as the development of suitable glucosinolate-free types in both rapeseed species would greatly increase the frequency of desirable plant types that could be obtained through interspecific crosses. This would make it possible to take advantage of the favorable combinations that can be achieved through this process. In the meantime interspecific crosses can be used as a means of introducing into *B. napus.* characteristics that are not presently available in that species, such as yellow seed and greater shattering tolerance.

S.H. Pawlowski,
CDA Research Station,
Saskatoon, Sask.

CANADA DEPARTMENT OF AGRICULTURE / MINISTÈRE DE L'AGRICULTURE DU CANADA

RESEARCH BRANCH / DIRECTION DE LA RECHERCHE

Central Experimental Farm
Ottawa, Ontario K1A OC6

Dr. S. C. Hudson,
Room 5009,
West Memorial Building,
Ottawa, K1A OH5.

YOUR FILE NO
VOTRE RÉF Nº

OUR FILE NO. 622/GI4
NOTRE RÉF Nº

November 1, 1971.

Dear Dr. Hudson:

Alternate Crops

I am supplying some information on peas, horse beans and lentils. I know you will get better information on mustard from Mr. S. Pawlowski, Saskatoon Research Station, so suggest you write to him.

Field Peas

I must caution you that data supplied are experimental plot data, which reflect ideal conditions and optimum management procedures. For example, plots may have been hand weeded and grown on fallow land. The variety Century has some resistance to some forms of root or foot rot (Aschochyta). All pea varieties grown are susceptible to mildew and damage from aphids. Data are from cooperative trials in 1970.

Summary data from 10 stations

	Yield Cwt/acre	%Protein	Wt of 1000 seeds gms	Days to Maturity
Century	15.6	23.7	212	88
Trapper	14.1	25.3	129	90
D.S. Green	12.3	24.1	171	87
M.P. 706	15.9	24.9	175	95

Peas can be grown anywhere in Canada. Maturity is not a problem, but yields are not high and because markets are limited, the acreage for peas is restricted. The crop can be handled with ordinary farm equipment. An expansion of peas as a livestock feed would create more demands for the crop.

Lentils

Our data on lentils are limited. They can be grown in Western Canada and are grown under contract. Lentils can be handled with ordinary farm equipment, except the crop varieties are short and harvesting is a problem. Careful attention must be paid to the ripeness of the crop for best quality.

Comparison of peas and lentils

	Yield Cwt/acre	Days to Maturity	Height Inches
Century Peas	17.5	88	35
Lentils	12.0	90	13

Horse Beans

There are many different varieties and two or three major types of horse beans. Our trials with horse beans have ranged from good successes to outright failures. In general the varieties from Europe will be late. The plants have sufficient height and pods are off the ground. We know very little about cultural practices. Plot yields are equal to peas, and beans have a comparative level of protein, approximately 25%.

I trust this information will be of some use.

Yours sincerely,

J. W. Morrison,
A/Assistant Director-General
(Planning & Coordination).

.MM

MANITOBA FOOD THINK

the Manitoba conference on business opportunities for processing agricultural products.

December 7, 8, 9, 1970
Winnipeg Inn,
Winnipeg, Manitoba, Canada

PEAS FOR FOOD AND FEED

Dr. Youngs: Our interest in field peas at the Prairie Regional Lab, stems from a rudimentary systems analysis of western Canadian agriculture. The prime purpose of agriculture is to produce food, and hopefully to produce this with the right proportion of main constituents, carbohydrates, fats and proteins for the market that it is supplying. In western Canada we have no difficulty in producing carbohydrate in the form of starch in wheat and our course grains. The rapid expansion of rapeseed acreage and the introduction of high-oil content sunflower seed provides the necessary source of fat or oil. Both of these crops, cereals and oil seeds, provide protein directly or through conversion to animal products, but here we run into an imbalance. Since our oil seeds are high in oil content, we satisfy our oil requirement long before we produce sufficient oil meal to supplement our cereals for animal feeds, and as a result, around 80,000 tons of soybean meal are imported annually into the four western provinces.

One way to overcome this imbalance would be to grow a low-oil content oil seed, such as soybean. Even if we had such a crop adapted to the prairies, we do not think this would be the best answer. A high oil content seed is more acceptable to the crusher, who can obtain a greater return of oil for a given throughput. Also if we could separate protein supplement production from oil and fat production, it would give us a flexibility not only to meet our own present requirements but also the varied needs of our export markets, and an ability to shift production to match future market changes. Our conclusion was therefore, that a crop grown primarily as a protein source could be very useful in balancing the overall agricultural production in western Canada.

The requirements of such a crop would be a protein content high enough that it would serve as a supplement to cereals and animal feed, a protein composition that complements that in our cereals to provide good nutritional balance, and a yield that makes it attractive to producers when priced competitively with other supplements. Since we are in the realm of supposing, we might add one more requirement. It should be readily processed into forms acceptable for direct human consumption. This last requirement could be very important to some of our export areas at the present time, and there is a growing interest in the direct use of more plant protein food in North America.

Although it may be possible to eventually develop a variety of crops meeting these requirements, through induced mutations, inter-specific crosses, etc. in the short term there are really only two general types of crops to be considered; the leaf or forage crops, and the green legumes. Leaf crops offer considerable potential in terms of protein production per acre, but there are problems with storage, shipping and handling. Fibre content tends to be high, and they are difficult to process into a form suitable for direct human consumption. These factors prompted us to opt for the grain legumes, which seem to have been completely neglected as a potential protein source in western Canada.

Initially, at least, we have been concentrating on the smooth, or field pea, Pisum sativum. Field peas possess a number of advantages as a crop. They are adapted to prairie climatic conditions, and can be handled by existing farm machinery. They can be stored and shipped like other grains, and their low fat level of about 1% suggests that rancidity or heating problems should be no more pronounced than in the cereals. Peas contain no known toxic materials, nor enzyme inhibitors, and should require no processing other than grinding for use in feeds. The raw flavour, although characteristic, is not unpalatable to animals, and on cooking becomes quite acceptable in certain foods, for example pea soup. These are all plus factors, but they do not answer the basic question of whether or not peas contain sufficient protein of a suitable composition so they could be economically produced as a feed supplement, or as protein source in foods.

Since protein content had not been considered as a quality factor in peas up to that point, no information was available on the protein in western Canadian varieties. Fortunately Dr. Ali-Khan at the Morden Research Station had saved samples from various selections that had been grown at a number of stations over several years, and we were able to analyze them.

Table I shows the mean value and the ranges for 10 varieties grown at Portage la Prairie, 1966, 1967 and 1968. The means for the three years varied by 1.6% protein, whereas the varietal variation averaged about 4%.

TABLE I

Protein Content (%) of 10 Field Pea Varieties Grown at Portage

	1966	1967	1968
Mean	27.4	26.3	25.8
Ranges	25.4-29.8	24.8-27.6	22.3-27.9

Table II shows the means and ranges for 19 varieties grown at four stations in 1968. The means between stations varied by 2.3%, and the varietal variation was about 5%. Variation between stations, years and varieties were all significant to the 1% level, and this highly significant variation between varieties demonstrated that increased protein levels can be obtained through breeding and selection. A search for high-protein germ plasm in the world pea collection has been undertaken in conjunction with Dr. Ali-Khan. Of 506 introductions checked so far, the range in protein content has been 22% to 32% protein. Protein levels of 25% to 30% with a possibility of going higher are encouraging if the amino-acid composition is well balanced.

TABLE II

Protein Content (%) of 19 Field Pea Varieties Grown in 1968

	Morden	Portage	Brandon	Ottawa
Mean	26.3	25.8	24.0	25.3
Ranges	23.5-29.1	22.3-28.0	22.3-26.6	22.6-27.6

Table III shows the content of essential amino-acids in the protein of field peas, rape, soybean and fish meals. As you will see by the table, peas are an excellent source of lysine and appear to be adequate in all other essential amino acids except methionine. This is low, and it is likely that supplementation with synthetic methionine will be required. However, chemical analysis of feed stuffs do not take account of digestibility or availability of nutrients, and actual feeding trials are required for final evaluation. Dr. Bell, of the Animal Science Department of the University of Saskatchewan, has provided this information for swine rations.

TABLE III

Essential Amino Acid Content of Various Feedstuffs (gms/16gmsN)

	Soybean Meal	Rapeseed Meal	Fish Meal	Field Peas
Lysine	6.5	5.3	7.8	7.9
Methionine	1.8	1.9	3.1	1.0
Leucine	8.1	6.7	8.2	7.8
Isoleucine	5.0	3.6	4.2	4.0
Threonine	3.7	4.2	4.3	4.3
Valine	5.1	4.8	4.8	4.5
Phenylalanine	4.8	3.8	4.1	5.1
Tryptophan	1.5	1.2	1.0	1.3

Table IV gives the growth and feed utilization data for a wheat-barley based ration, protein supplementation being provided by one, a 7% soybean fishmeal blend, two, 24% field peas, and three, 24% field peas plus synthetic methionine. There were no significant differences in either weight gain or feed gain ratio for any of these rations. The protein in the peas was equivalent to that of the soybean fishmeal blend in promoting growth, and the combination of the Cereals plus the peas did not lack in methionine, as no improvement was shown by its addition. It appears that for swine rations at least, the field peas answer our first two requirements and do provide sufficient protein of a composition that does complement that in our cereals.

Dr. Bell and Mr. Wilson of the Agricultural Economics Department, U. of S. also looked at the economics of the use of peas. They concluded that farmers growing feed for their pigs would be money ahead if they could produce peas at $1.85 per bushel or less under prices prevailing for other feeds at the time of the study, and that was the fall of 1969. If the peas were to be handled by feed manufacturers the price to the grower would be reduced by the shipping and handling charges for both the peas to the mill and the completed feed or concentrate back to the farm and this would put them in the range of $1.40 to $1.50 per bushel.

Mr. Rogalsky of the Manitoba Department of Agriculture has estimated the cost of production at $2.10 per bushel for a 15-bushel per acre yield, $1.56 for 20-bushels per acre, and $1.05 for 30-bushels per acre. The average yield reported by DBS over the past 10 years has been 19.9 bushels. Peas should therefore be profitable, under present conditions, for on-the-farm feeding of pigs. If, through plant breeding, improved cultural practice, or both, we could raise the average yield to 25 or 30 bushels, they could enter the formulated feed market, and should also be a good possibility for export to areas that import both protein supplement and feed grains. We do not think that the figure of 30 bushels per acre is an unreasonable one. There has been very little work on peas from the point of view of obtaining high yields with high protein and ignoring factors such as colour and cooking quality. A concerted effort in this area by Federal, Provincial and University Agriculture departments could well pay off.

TABLE IV

Growth and Feed Utilization Responses of Individually-Fed Pigs

	Avg. Daily gain (gm.)	Feed/gain ratio
Control: soybean-fish meal	703	3.25
Field Peas	704	3.06
Field Peas + Methionine	694	3.11

The other major use of protein supplements in feeds is in poultry rations. Drs. Moran, Summers and Jones at the University of Guelph have investigated this area. Table V shows the effect of the addition of peas to a practical starting diet for broilers. We have two controlled rations, a corn soybean and a corn-soya-feather ration. In diet three the soybean meal was completely replaced by peas, either raw or pelleted, and this meant that they were 65% of the diet and in diet four 58% of the soybean meal was replaced by peas and in this case they were 35% of the diet. Complete replacement of the soybean meal, particularly with raw peas depressed the gain feed ratio and significantly lowered the weight gain. However at moderate levels, of pelleted peas in diet four, performance was not significantly different from the controlled. The above authors also included 15% and 30% raw and pelleted peas in laying hen rations. Here pelleting had no significant effect and it was concluded that extensive quantities of raw peas could be used for laying hens.

No estimate of economics has been made in this case, but I understand that Dr. Bell is presently applying parametric linear computer programming to the problem.

The trend to very high energy, and corresponding high-protein diets for broilers, emphasizes the need for high-protein peas if we are to penetrate this market. An alternate, or adjunct to doing this by plant breeding, would be to concentrate the protein in peas through processing.

TABLE V

Performance of Broiler Chick on Diets Containing Raw and Pelleted Peas

Diet		3 week wt (gms)	Gain/Feed
1. Corn-soybean meal		285	0.62
2. Corn-soy-feather meal		275	0.60
3. Corn-feather meal	– raw peas	201	0.51
	– pelleted peas	241	0.55
4. Corn-feather-soy	– raw peas	248	0.58
	– pelleted peas	276	0.62

The other major component of peas besides protein is starch, and at the Prairie Regional Lab we have developed an alkaline wet-milling process to separate these two major constituents. Protein in ground peas is dispersed by milling in dilute lime water. Starch granules are removed by centrifuging and the total supernatant then drum-dried to give the relatively bland light tan coloured protein concentrate. Starting with de-hulled pad flour, 24.5% protein, we obtain 36% as a protein concentrate, with 64.4% protein, 64% of the starch fraction, with 1.8% protein in the starch.

TABLE VI

Products from Alkaline Wet Milling of Peas

Dehulled Flour

24.5% protein
55.0% starch

Starch Fraction

87 % starch
1.8% protein

Protein Concentrate

64.4% protein

Nutritive value of this pea protein concentrate, PPC, was checked by Dr. Bell, using mice. Table VII shows the response to purified diets with 15% protein being supplied solely by PPC, by PPC plus methionine, fish protein concentrate (FPC), egg and casein plus methionine. As anticipated by the amino acid composition, when peas are the sole source of protein, there is a methionine deficiency. However, on methionine supplementation, PPC is an excellent protein source, equivalent to egg or methionine supplemented casein and significantly better than FPC with mice as the test animal.

PPC has also been tested as an ingredient in turkey rations by Dr. Dunkelgod at the Swift Current Research Station. Just before coming I received a preliminary result from Dr. Dunkelgod, comparing it to soybean or replacing soybean meal. He found that the weight gained was equivalent, but the feed efficiency was significantly better for the PPC. Compared to Fish Protein Concentrate, the feed efficiency of PPC and FPC were the same, but the FPC did show somewhat better weight gain.

Grant Royan, a graduate student with Dr. Bell, is presently testing PPC as a constituent in milk replacer for calves. Replacement of part of the skim milk by part of the PPC plus whey powder appears quite encouraging in terms of dry matter and protein digestability, weight gains and feed conversion. PPC plus glucose, instead of whey powder is also being tried. Carrying this one step further, we have hydrolized the starch in whole pea flour enzymatically to produce a product that is primarily glucose and protein. This is currently being incorporated into milk replacer at a 50% level, and we have no final results in this. It appears that dry matter digestability is going to be down somewhat, but since this would be a considerably cheaper product, it may well be of economic value.

TABLE VII

Effect of Various Protein Sources at the 15% Protein Level in Purified Diets for Mice

	Wt. Gain	Feed/Gain Ratio
P.P.C.	6.4	7.3
P.P.C. + methionine	12.9	4.0
F.P.C.	9.5	5.5
Egg	11.1	4.4
Casein + methionine	10.0	4.8

Separation of starch and protein may also be accomplished by fine grinding and air classification. Table VIII shows the protein content of 20 fractions obtained by a batch classification of pin milled pea flour by Mr. Black at the Grain Research Lab. Here you can see we run from protein contents of 60% down to a low of about 5.8% in the 75% to 80% cut. Assuming that a similar separation could be obtained on a continuous commercial unit, a 50-50 split could be expected to yield protein on a level of 38.5% and 7.8%. Air classification would be a much less costly procedure than wet-milling, but it is still too early to obtain a good estimate of the economics of processing peas for these various applications. We feel that they certainly warrant further investigation.

TABLE VIII

Air Classification of Pin Milled Pea Flour

Fraction	% Protein	Fraction	% Protein
0-5%	60.2	50-55%	9.1
5-10	60.4	55-60	8.3
10-15	58.9	60-65	7.2
15-20	47.5	65-70	7.0
20-25	37.5	70-75	6.4
25-30	39.7	75-80	5.8
30-35	28.2	80-85	5.8
35-40	23.3	85-90	6.9
40-45	16.7	90-95	7.7
45-50	12.1	95-100	13.3
Avg. 0-50	38.5	Avg. 50-100	7.8

Turning then briefly from feed to food, the work on feeds has shown that methionine supplemented pea protein, or pea protein plus cereal protein provides excellent nutrition. Also we have a variety of materials to work with to develop food products. Pea flour, PPC, hydrolized pea flour and pea starch. There has been a great deal of interest recently in the production of meat analogues from materials such as spun soy protein.

Working with Mr. Sumner of the Food Technology section, Department of Home Economics, University of Saskatchewan, we have developed a textured product from PPC. This is a somewhat novel process which would be considerably cheaper than spinning, and we feel gives a good meat-like texture. Patent application is presently under consideration for this process.

However, the main advantage of using plant protein in place of meat is the lower cost. Much of this advantage may be dissipated in processing plant proteins to look, taste and chew like meat. In the long term, the real place for the inclusion of additional plant protein, may be in such products as bread, breakfast cereals, pasta products, snack foods, and baked goods in general.

This slide shows the effect of the addition of pea flour to wheat flour for bread making. The baking was done by Mr. Teed of the Cereal-Chemistry Department, University of Saskatchewan, and represents the addition of 0 to 25% pea flour in 5% steps, starting in the upper right hand corner and progressing to the lower left hand corner. Up to 10% pea flour, the loaf volume and texture, although not quite up to the control, appeared to be quite acceptable, but 10% pea flour is not sufficient for a high protein bread of good nutritional balance. If we use PPC instead of the whole flour, we get much the same effect on baking properties, only now at the 10% addition level we have protein of around 20% dry basis, with a good blend of cereal and pea protein. Neither the flour nor the PPC gave any detectable flavours at the 10% level.

Results of the addition of pea flour or PPC to durum semolina for spaghetti production were not so promising. Dr. Matsuo of the Grain Research Lab found that even small additions resulted in poor colour and cooking quality. Whole pea flour can be used to produce snack foods. Extrusion of a dough of simply pea flour, salt and water into a deep fat fryer, gives a product a good texture, with no trace of the pea flavour.

If we were to produce PPC we would have to have a market for the resulting starch. One possible outlet would be as an adjunct to the brewing and distilling industry. Dr. Sosulski, Crop Science Department of the University of Saskatchewan, had a test run for us by a commercial distillery. Comparing it to potato starch, they found that it cooked better and gave a higher yield of alcohol. It did not contribute to the flavour of the distillate. Dr. Schaus of Canadian Breweries has also tested pea starch as a brewing adjunct, and found that it gave a satisfactory product. Use of pea starch in this area would depend on a continuing supply at an attractive price.

There are many other food products in which field peas or their products could be used. We haven't even touched on their present major use in soups and canned products, but since both time and my knowledge of this are very limited, we will not go into that.

In conclusion, then, peas in food and feed, we would say "yes." It may not be tomorrow, but with work by plant breeders, agronomists, nutritionists, food technologists and processors, we feel that there is a real potential for expanding the production and use of field peas in western Canada.

Thank you.

Mr. McRorie: Thank's very much Dr. Youngs. Traditionally I think we have referred to rapeseed as a Cinderella crop. After listening to Dr. Youngs, the thought occurs to me that there may yet be another Cinderella lurking somewhere in the background, and I'm sure that we are going to hear more about peas as a source of food and feed in the future.

Our first speaker of the second session this morning, Mr. Nelson brought us the story on wild rice supply, and of course he is a very welcome guest from our friendly nation to the south. At this time I would also like to extend a similar welcome to another speaker from the south, Dr. E. H. Rinke, Director of Plant Breeding, Northrup King and Co. Inc., Minneapolis.

CANADA DEPARTMENT OF AGRICULTURE / MINISTÈRE DE L'AGRICULTURE DU CANADA

RESEARCH BRANCH / DIRECTION DE LA RECHERCHE

Ottawa Research Station

Dr. S. C. Hudson,
Room 5009,
West Memorial Building,
Ottawa, Ont.
K1A 0H5.

YOUR FILE NO
VOTRE RÉF Nº

OUR FILE NO
NOTRE RÉF Nº

Ottawa, Ontario,
K1A 0C6.

Nov. 2, 1971.

Dear Dr. Hudson:

Thank you for your letter of Oct. 22, 1971 concerning my work on high protein oats. It is very difficult to get anyone interested in the oat crop these days so that I welcome the opportunity to discuss my projects with you. I will give you some of the background information on how and why I became interested in high protein oats and some of the data I have collected. You may take the information you require for your report.

I believe that the oat crop is a highly under rated crop in Canada both from the research and production standpoints. In making an appraisal of the potential of any feed grain one must ask the question - "what uses have we asked of the species and how much effort have we put into moulding the crop to better serve us?" Related to this question is another which asks, "If we asked plant breeders to breed a different oat for a new purpose - is the genetic variability available within the crop sufficient to obtain the desired result?" My answer to the first question is that we have bred oats for one purpose and have asked it to function efficiently in a great number of ways. We plant it early and late mainly on stubble land or marginal land. We use it as a companion crop, a hay crop, a silage crop and a pasture crop. No other feed grain is asked to "fill-in" like the oat crop within the farm operation. If we want to use oats in such a wide variety of uses I believe we should breed oats to effectively meet these requirements. We need an inventory of varieties.

My answer to the second question is that the oat crop contains as much and maybe more genetic diversity as all our common cereal grains. We have a great number of wild species and the crop has not been selected by man to the same extent as wheat, corn, barley or rice. Canadian plant breeders hold a major portion of this variability in their seed files.

Several years ago Dr. F. Zillinsky, former Chief, Cereal Section, O.R.S., carried on an extensive program of interspecific hybridization in oats. He did an enormous amount of work in combining genes from wild species of oats (i.e., A. strigosa and A. sterilis) with the common species A. sativa. Dr. Zillinsky left O.R.S. to join CIMMYT in Mexico to work on the Triticale crop but he left his material. I worked with Zillinsky on his material and was appointed to his position when he left.

It seemed clear to both Zillinsky and myself that the acreage of oats would continue to decline unless ways could be found to improve the stature and usefulness of the crop. I have embarked on a vigorous research campaign to try and make the oat crop more useful in Canada.

It is my belief that we in the agricultural sciences have a responsibility to keep all of our agricultural plant species in as high a state of refinement as possible to provide both our consumers and our producers with as much flexibility in the future as possible.

Two of the most important characteristics of the oat crop are its wide adaptability and its nutritional qualities. I am trying to further improve the adaptability of oats by breeding daylength-insensitive oats. This has been done successfully in wheat (Pictic and other Mexican varieties) and rice (I.R.8 and other varieties coming from the International Rice Research Institute). We will be testing our first selections for yield and adaptability in 1972. The lipid content of oat groats is higher (3-8%) than that of either wheat or barley (2-3%) and its degree of unsaturation is good. Its quality approaches that of corn oil. Lipase activity is fairly high which may result in certain storage problems but storage facilities have improved greatly in the past few years and new techniques are available (propronic acid storage for example).

The protein content of oats varies considerably and, as with wheat, the greater the protein content the lower the yield potential. This is the rule but it is the exceptions that are important in plant breeding. The amino acid spectrum of oat protein is similar to other cereal grains except that nutritionists claim it to be better balanced. The lysine content of any variety of oat is as high as high lysine corn. Other essential amino acids are at least equal to other cereals.

The fiber content of oat grains is high but this really does not present a problem. Genes governing the hulless condition are available in a number of stocks and we now have hulless strains that yield as many groats per acre as our best hulled varieties (limited tests).

I became interested in trying to select high protein lines out of Dr. Zillinsky's interspecific material. It seemed clear that protein was going to be important in the World and that his very variable plant material was a good place to start selection. Many selections were made and several were distributed to interested scientists. One selection O.A.123-33 was selected for its high protein content and its ability to remain erect in the field. The Americans (Quaker Oats Co. of Illinois and USDA at Beltsville) were quite interested in this oat and I have been told that Quaker Oats has grown the oat under contract to test its usefulness in the manufacture of high protein baby foods. American researchers are very interested in high protein oats. They are working primarily with selections from the species _A. sterilis_ which is really a wild oat. Much breeding work must be done to improve their material but recent reports are that they are progressing rapidly. My own view is that any advantage we might of had has or will soon be lost because of inactivity in Canada. We don't have industry tied in the same way the Americans have. Their basic research effort in product development is located at home, whereas, ours is almost non-existent and we have to rely upon American firms to develop products to sell our crops. Most of these firms are more interested in exploiting the U.S. corn crop that participating in any advantages we may have in our own crops.

...... 3

I tested O.A.123-33 in various parts of Canada in 1969. I enclose a table with data on yield/acre, % protein and protein/acre, for the check variety Victory and O.A.123-33. The difference in percent protein between these two varieties is measurable and consistent across the country. However, the yield of protein per acre is almost identical for the two. This is as expected and is the same kind of result one might obtain for wheat. The only way I believe we can improve the yield of O.A.123-33 is to change the method of growing it. It is a relatively small statured plant and possibly closer spacing on highly fertile soils may improve its yields. Another way may be to use it as a companion crop. Since it would not shade the legume crop excessively the reduced yield per acre of oats may be compensated for by an increased growth of legume.

Some workers claim that we should not worry too much about trying to improve the yield of high protein oats. They feel that if it is possible to produce a high protein feed on the farm that this would eliminate the problem of buying expensive soybean protein concentrates. They claim that just the trucking, handling and storage charges associated with the selling of corn to purchase soybean meal would offset a drop in oat yield potential. They want to use oats as a speciality crop for protein rather than the accepted energy source. They want to mix high protein oats (preferably a crop with lots of straw) with high energy corn to feed livestock and poultry. It remains to be seen if oat protein is balanced enough for this role but we need testing.

I have included some data on the protein content, fat content and fiber content of O.A.123-33 grown at Regina in 1970. I am sorry that I have no data on energy content. I am hopeful that our new quality laboratory in O.R.S. will begin to assess energy values in the future but this may take some time to initiate. I also include some amino acid profiles that may be of use to you. At the present time the profile of O.A.123-33 does not appear to be any different from that of many common oat varieties.

It may be of interest to you to learn that quantities of O.A.123-33 are being fed to swine at Lennoxville and to turkeys at Swift Current. The Kentville College of Agricultural technology is very interested in high protein oats and will evaluate it as a feed for laying hens and dairy cattle.

This is a lengthy letter but it only opens the subject. I don't know how far to proceed with high protein oats in the future. If someone can take this oat or some of our other strains and establish a role or market for oat protein we can forge ahead. At this point I don't care if this exploitation is done at home in Canada or abroad. I have one objective - has oat protein a place in the manufacturing of foods in Canada, Japan or wherever. I say if we can't do the research let's try to get the material into the hands of those who will try to make an evaluation. We have plenty of seed (50 acres grown at Indian Head last year) and the ability to grow more. We also have some of the equipment and manpower to mount a substantial breeding program if it becomes important to do so. The oat crop is far from dead - its exciting from a research standpoint and has a great potential from a practical standpoint.

If I can be of further assistance please feel free to write or telephone.

Yours sincerely,

Vernon Burrows.

Vernon Burrows,
Chief, Cereal Section,
O.R.S.
VB/lk
Encls.

Analysis of O.A.123-33 oats grown at Regina in 1970.

	Whole kernel	Oat groat	Oat hull
Protein (%) (N × 6.25)	17.30	23.02	2.20
Ether extrat(%) (fat)	4.52	5.76	0.58
Fiber (%)	9.74	2.11	34.45

<u>Amino acids present on a 16 gram N. basis</u>

	O.A.123-33	Oat varieties*
Lysine	4.0	4.2
Histidine	2.3	2.2
NH3	3.1	2.7
Arginine	6.9	6.9
Aspartic	9.2	8.9
Threonine	3.2	3.3
Serine	4.1	4.2
Glutamic	22.6	23.9
Glycine	4.7	4.7
Alanine	4.8	5.0
Cystine	1.7	1.6
Valine	5.4	5.3
Methionine	2.8	2.5
Isoleucine	4.0	3.9
Leucine	7.5	7.4
Tyrosine	2.9	3.1
Phenylalanine	5.6	5.3

* Amino Acid Composition of Oat Groats
Geo. S. Robbins, Y. Pomeranz and Lee Briggle
Agric. and Food Chemistry, Vol. 19, No. 3, 536-39, 1971.
- note these figures represent an average of 289 oat varieties.

Crude protein percentage (N x 5.7), protein per acre and yield of Victory and O.A. 123-33 oats grown in the Eastern and Western Canadian cooperative oat tests in 1969.

		Victory			O.A. 123-33		
Eastern Canada		Yield hundred pounds/ ac.	% prot.	P/ac. (lb.)	Yield hundred pounds/ ac.	% prot.	P/ac. (lb.)
Atlantic Prov.							
Charlottetown,	P.E.I.	34.3	12.5	391	26.6	15.9	385
Nappan,	N.S.	17.0	17.9	277	17.8	20.2	328
Fredericton,	N.B.	13.8	15.7	198	16.7	18.4	280
	Av.	21.8	15.4	289	20.4	18.2	331
Quebec							
Normandin		24.5	13.9	311	21.1	16.7	321
Lennoxville		33.0	14.3	430	27.7	17.6	445
Macdonald Coll.		27.5	11.6	291	18.2	16.8	279
La Pocatière		33.7	13.0	399	24.4	17.2	379
	Av.	29.7	13.2	358	22.8	17.1	357
Ontario							
Kapuskasing		25.4	11.1	257	16.1	14.0	205
Ottawa		31.8	13.7	398	24.9	19.1	434
Kemptville		18.3	13.1	219	13.5	18.7	230
Thunder Bay		26.7	15.8	385	21.6	19.2	378
Guelph		22.2	14.1	285	19.9	15.6	283
New Liskeard		24.3	13.7	304	16.2	15.5	229
Ridgetown		36.1	14.6	481	27.9	18.0	458
Brant		38.9	12.3	436	24.5	16.5	368
	Av.	28.0	13.6	346	20.6	17.1	323
Average East		27.2	13.8	337	21.1	17.3	334
Western Canada							
Manitoba							
Morden		17.5	15.0	240	18.2	16.6	275
Portage		29.5	16.3	439	22.1	18.4	371
Brandon		23.3	16.1	342	17.2	19.4	305
	Av.	23.4	15.8	340	19.2	18.1	317
Sask.							
Indian Head		30.7	14.8	414	21.8	20.0	398
Melfort		36.1	15.7	517	39.5	17.9	645
Regina		26.5	15.7	379	21.4	19.2	375
Saskatoon		40.6	15.6	577	36.8	18.5	621
Swift Current		17.8	15.5	252	20.8	17.7	336
Scott		41.6	14.6	554	28.6	18.5	482
	Av.	32.2	15.3	449	28.2	18.6	476
Alberta							
Edmonton		38.6	14.3	503	33.8	17.1	527
Beaverlodge		18.2	15.7	261	14.2	18.6	240
	Av.	28.4	15.0	382	24.0	17.9	384
Average West		29.1	15.4	407	24.9	18.4	416
Total Average		28.0	14.5	367	22.7	17.7	368

Issued under the authority of
The Honourable Otto E. Lang
Information Canada 1973